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RADC-TR-77-270, Volume III (of three)
Final Technical Report
August 1977

UNATTENDED/MINIMALLY ATTENDED RADAR STUDY
Radar Costs

ITT Gilfillan

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This report has been reviewed and is approved for publication.

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Project Engineer

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JOSEPH L. RYERSON
Technical Director
Surveillance Division

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

UAR - Unattended Radar
MAR - Minimally Attended Radar
DEWLine
Life Cycle Cost
Surveillance
Reliability

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The volume presents the Life Cycle Cost analyses of alternative radar design approaches that could be developed to optimally satisfy requirements for unattended and minimally attended radar operations. The requirements, detailed in the study statement of work, consist of two sets of nominal radar performance parameter goals; one set for the unattended radar (UAR) and a second for the minimally attended radar (MAR). Based on these requirements, alternative radar design approaches were synthesized for both UAR and MAR, and evaluated for reliability, life cycle cost (LCC), and performance. (cont'd)

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The radar designs recommended for UAR nad MAR displayed the greatest potential for optimally satisfying all stated requirements. These designs are detailed in Volume II of the report. The UAR, a 60 nmi 2D radar, automatically outputs target track data that can be remoted to manned logistics nodes and/or ROCCs via narrowband communications links. It provides all altitude surveillance coverage of aircraft targets between 100 and 100,000 feet, and is configurable to be sufficiently reliable to guarantee, to a >90 percent confidence level, failure-free system operation for periods of time from three months to one year. The MAR, a 200 nmi 3D radar, also automatically outputs target track data to logistics nodes and/or ROCCs. It provides all altitude 3D coverage of aircraft targets between 100 and 100,000 feet, and is configurable to be sufficiently reliable to guarantee, to a >90 percent confidence level, failure-free system operation for periods of time from five days to 0.5 month.

Volume I provides an Executive Summary of the Unattended/Minimally Attended Radar Study. Volume II presents alternative approaches investigated and details the radar designs recommended. Volume III presents data estimating radar acquisition and Life Cycle costs.

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EVALUATION

The effort reported is one of three parallel study contracts performed under Project E233 by direction of ESD/XR. These reports identify alternative concepts and activity necessary to support the development of a short-range, unattended radar and a long-range minimally attended radar. The short-range radar is being viewed for application in DEW Line to replace the AN/FPS-19 and the long-range radar is being viewed for application by the Alaskan Air Command to replace the AN/FPS-93. These studies provide the assurance that current technology can support the development of unattended/minimally attended radars that offer improved performance and can significantly reduce operating and maintenance costs.

These efforts were performed in accordance with 1978-1982 TPO III, Thrust C Advanced Sensor Technology. The results will be used by ESD to develop system acquisition strategy for SEEK FROST (Project 2448), PE 12412F. It also provides supplemental data supporting SEEK IGLOO (Project 968H), PE 12325F.

Adrian S. Briggs

ADRIAN S. BRIGGS
Project Engineer

1.0 INTRODUCTION

This volume discusses life cycle cost (LCC) analyses and data pertaining to a short range, 2-dimension (2D) unattended radar (UAR) and a long-range, 3-dimension (3D) minimally attended radar (MAR).

LCC emphasis has been placed on the UAR since it represents an extreme departure from current radar support philosophies and involves a unique design approach. During evolution of the UAR design, LCC analyses were performed on design alternatives utilizing two computer math models: The RCA PRICE model and the ITTG OPSTOCK/CONSUME model. The PRICE model was used to assess the radar's acquisition costs and the ITTG model was used to assess logistics effects of the designs. Results of these analyses are combined in this LCC study.

The UAR LCC data furnished is limited to that indicated by the study statement-of-work (SOW). The SOW indicated that personnel logistics, power requirements, transportation (surface and air), and disposal should not be included in the analysis. Reference has been made to some of these items, but they are not included as cost elements.

The LCC data was developed, in part, by cost estimating relationships and, in part, by direct pricing analysis of the specific program elements. The derivation of system reliability is documented in Volume II. Unit level reliability data are based on unit planning documents using MIL-STD approaches. Maintenance and personnel requirements were obtained from the math models and maintenance engineering analysis of the equipment in its intended operational environment.

The LCC analysis data on the MAR is based on concepts and techniques employed on a current ITTG product line radar which is optimized for low life cycle costs.

2.0 LIFE CYCLE COST (LCC)

2.1 UAR Life Cycle Cost (LCC) Analysis

A modified version of the standard LCC algorithm is used to describe the life cycle cost aspects of the UAR program.

$$LCC = A_T + I_L + \sum_{i=1}^{N} RL$$

where:

AT = Acquisition Cost Total
I_L = Initial Logistics Cost
R_L = Recurring Logistic Cost (Annual)
N = Number of Years in the Life Cycle.

2.1.1 Cost Elements Considered

The cost elements considered in the LCC analysis consist of the following:

- Acquisition Cost Total
  - Research and Development
  - Prototype Development
  - Performance, Environmental, Reliability Testing
  - Production
- Initial Logistics Cost
  - Spares
  - Inventory Entry
  - Personnel
  - Training
  - Tools and Test Equipment
  - Technical Documentation
  - Installation and Checkout
- Recurring Logistic Cost (Annual)
  - Spares Replenishment
  - Inventory Management
  - Personnel
  - Training
  - Depot Maintenance Manhours
  - Maintenance Administration
  - Tools and Test Equipment Maintenance
  - Preventive Maintenance

2.1.2 Configuration Alternatives Considered

The UAR study considered three reliability configurations which are defined by reliability data furnished in Volume II, and the equipment breakdown and LCC data listing furnished in Section 2.2.2 of this volume. The three configurations are:

- Three-month system where the probability of zero failures in a three-month interval is 0.931.
- Six-month system where the probability of zero failures in a six-month interval is 0.908.
- And, a twelve-month system where the probability of zero failures in a twelve-month interval is 0.909.

The LCC calculations are given in Paragraph 2.6. The three-month system has merit not only on the basis of lower life cycle costs but also because it more effectively utilizes the support organization. As indicated by Figure 2.1-1, higher reliability configurations make fewer demands on the support structure, particularly in relationship to on-site maintenance requirements. If there is a problem associated with high reliability, it is the resulting inactivity of maintenance personnel which causes boredom and gradual degradation of skills. The three-month system is not a completely effective solution to this problem, but does improve personnel utilization.

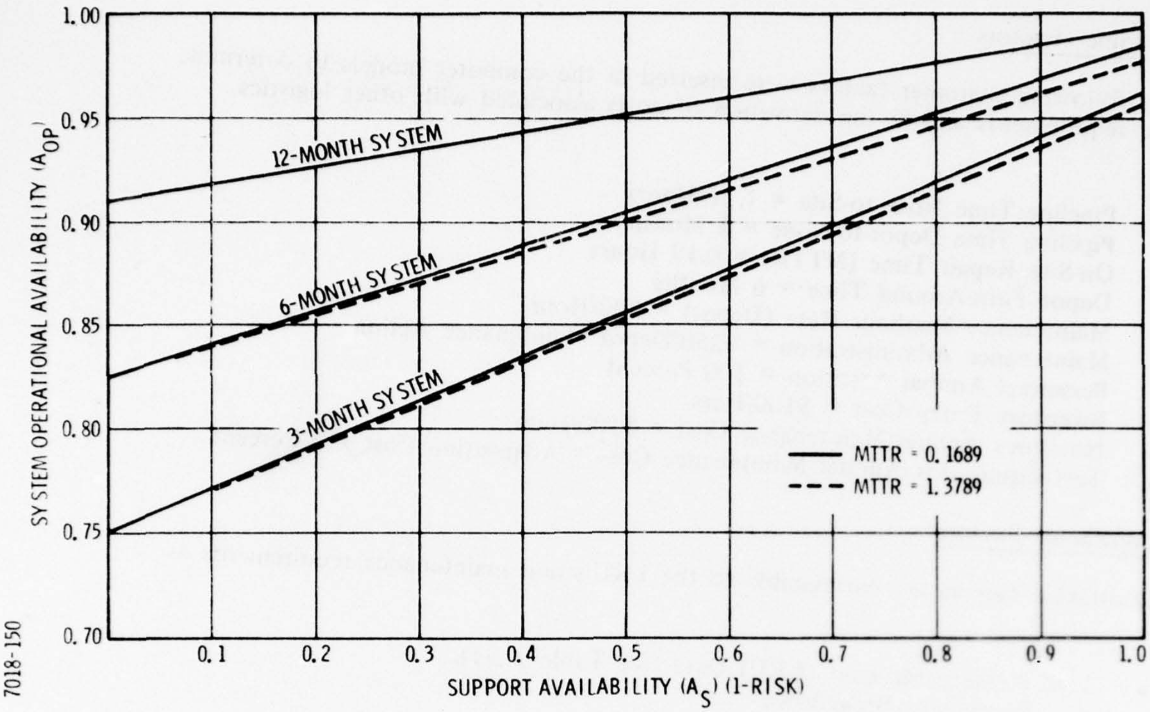

Figure 2.1-1. Support Availability (A_s) (1-Risk)

Figure 2.1-1 graphically depicts how operational availability (Aop) is achieved through a combination of reliability and support availability. The higher reliability equipments require less external support to achieve availability objectives for short term. However, the use of redundancy to achieve high reliability increases the amount of hardware, which translates into higher acquisition costs and more hardware to support.

On the graph in Figure 2.1-1, the Aop vs A_s curves for the three configurations are shown with solid lines representing the MTTR exclusive of travel time to the site, while dashed lines include the 1.21-hour mean transportation time. Assuming an Aop objective of 0.9 and the inclusive travel time MTTR, A_s is 0.75 for the 3-month system and 0.5 for the 6-month system. When this is translated into risk for shortage of 0.25 and 0.5 respectively, it can be used to estimate the cost of initial spares required. (Reference Figure 2.1-5.)

2.2 Program Variables

The LCC computation is based on the following program variables:

- Number of Years in Life Cycle = 20 Years
- Number of Operating Systems = 80 Systems
- Operating Time per System = Full Time = 168 Hours/Week
- Operational Availability (Aop) Objective ≥ 90 Percent

2.2.1 Customer Factors

The following customer factors were inserted in the computer models to determine support spare requirements and in the derivation of costs associated with other logistics elements:

- Pipeline Time Node-to-Site = 1.21 Hours
- Pipeline Time Depot-to-Node = 1 Month
- On-Site Repair Time (MTTR) = 0.17 Hours
- Depot Turn-Around Time = 6 Months
- Maintenance Manhour Rate (Depot) = $20/Hour
- Maintenance Administration = $250/Depot Maintenance Action
- Personnel Annual Attrition = 100 Percent
- Inventory Entry Cost = $100/Item
- Inventory Annual Maintenance Cost = $100/Item
- Test Equipment Annual Maintenance Cost = Acquisition Cost x 5 Percent

2.2.2 Contractor Factors

Contractor factors are correlatable to the LRU's and maintenance requirements as follows:

- Line Replaceable Unit (LRU) Data (see Table 2.2-1).
  - Equipment Breakdown
  - Quantity of Each Type LRU
  - LRU Failure Rate
  - Node NRTS (Not-Repairable-This-Station) Rate
  - Depot NRTS Rate
  - On-Line MTTR
  - Off-Line MTTR
  - Unit Price
  - Cost-to-Repair

- Personnel and Skill Requirements
- Preventive Maintenance Requirements
- Tools and Test Equipment Requirements
- Codification Requirements

2.3 Maintenance and Support Philosophy

To support 80 unattended operating locations, a network of intermediate repair locations (nodes) and a single depot is recommended. Six nodes will be located at existing military sites which can accommodate airlift, as well as helicopter operations. A single new node site is required.

TABLE 2.2-1. EQUIPMENT ASSEMBLY BREAKDOWN AND LIFE CYCLE COST DATA LISTING
SYSTEM NAME: UAR – UNATTENDED SHORT RANGE RADAR, SURVEILLANCE, 2D

Item No.	Part Number	Ident Lvl	Description	Quantity 3 Mo Active	Stdby	6 Mo. Stdby	12 Mo Stdby	Failure Rate 10^6	NRTS Rate Node	Depot	MTTR On Line	Off Line	Price Data Unit Price	RPR Cost
01	60000	1	Radar Set, UAR	1										
02	61000	2	Antenna Group	1	0	0	0	0.842	–	–	–	–	136,625.00	–
03	61100	3	Antenna Assy	3	0	0	0	0.001	–	–	–	–	42,275.00	–
04	61110	4	Antenna Array	12	0	0	0	0.001	–	–	–	–	5,000.00	–
05	61120	4	Antenna Reflector, Dual	3	0	0	0	0.001	–	–	–	–	20,775.00	–
06	61150	4	Diplexer Radar/IFF	12	0	0	0	0.001	–	–	–	–	750.00	–
07	61200	3	Antenna Array, IFF	12	0	0	0	0.001	–	–	–	–	750.00	–
08	61300	3	Antenna Assy, ONMI	1	0	0	0	0.001	–	–	–	–	800.00	–
09	62000	2	Microwave Group	1	0	0	0	0.800	–	–	–	–	40,813.00	–
10	62100	3	Waveguide	1	0	0	0	0.001	–	–	–	–	31,725.00	–
11	62150	4	*Drier Assy	13	0	0	0	0.001	1.00	1.00	0.1	0.0	30.00	30.00
12	62200	3	Switch Driver Assy	1	0	0	0	0.619	0.10	0.15	0.1	0.9	7,338.00	75.00
13	62300	3	*Switch Module R.F.	13	0	0	0	0.157	0.10	0.01	0.2	1.1	100.00	60.00
14	62400	3	Diplexer IFF/ECM OMNI	1	0	0	0	0.001	1.00	1.00	0.5	0.0	450.00	450.00
15	63000	2	Equipment Mounting GP	1	0	0	0	0.425	–	–	–	–	16,963.00	–
16	63100	3	Mounting Assy	1	0	0	0	0.010	–	–	–	–	7,500.00	–
17	63200	3	Cabling Installation	1	0	0	0	0.317	–	–	–	–	9,463.00	–
18	64000	2	Radar Transmitter	1	0	0	0	2.152	0.00	0.00	0.3	0.0	54,562.00	1,050.00
19	64100	3	Cabinet Transmitter	1	0	0	0	0.131	–	–	–	–	812.00	–
20	64200	3	*Amplifier Module RF	22	5	5	5	1.915	0.20	0.05	0.1	2.0	750.00	140.00
21	64300	3	Pwr Divider Preamp, 3 Way	1	0	0	0	0.001	1.00	0.10	0.4	2.0	1,500.00	75.00
22	64400	3	Pwr Combiner, Preamp, 3 Way	1	0	0	0	0.006	1.00	0.10	0.4	2.0	1,500.00	75.00
23	64410	3	Monitor Assy	1	0	0	0	0.259	0.10	0.01	0.1	1.0	13,500.00	50.00
24	64500	3	Power Divider, 24 Way	1	0	0	0	0.001	1.00	0.10	0.4	2.0	8,500.00	200.00
25	64600	3	Power Combiner, 24 Way	1	0	0	0	0.006	1.00	0.10	0.4	2.0	8,500.00	200.00
26	65000	2	*Radar Receiver, R.F.	2	0	0	1	1.505	0.01	0.0	0.5	1.1	4,994.00	1,150.00
27	65050	3	Cabinet Radar Rec, R.F.	2	0	0	1	0.001	–	–	–	–	400.00	–
28	65100	3	Limiter STC, Substrate	2	0	0	1	0.280	0.9[illegible]	0.10	0.0	2.0	1,094.00	62.00
29	65200	3	RF Preamp, Substrate	2	0	0	1	0.205	0.20	0.10	0.0	2.0	1,500.00	84.00
30	65300	3	Mixer Assy, RF	2	0	0	1	0.200	0.20	1.00	1.0	1.0	1,250.00	20.00
31	65400	3	Lin-Log Amplifier	2	0	0	1	0.715	0.90	0.10	0.0	2.5	750.00	62.00
32	65500	2	*Radar Receiver, IF	1	0	0	1	1.234	0.01	0.0	0.5	1.0	5,232.00	1,500.00
33	65550	3	Cabinet Radar Rec, IF	1	0	0	1	0.001	–	–	–	–	400.00	–
34	65600	3	IF Amplifier Substrate	1	0	0	1	0.378	0.95	0.10	0.0	2.0	1,500.00	64.00
35	65700	3	Chirp Line Assy	1	0	0	1	0.524	0.90	0.15	0.0	1.2	1,750.00	67.00
36	65800	3	Quad Detector Assy	1	0	0	1	0.241	0.90	0.05	0.0	2.5	1,582.00	55.00
37	66000	2	Freq Synthesizer	1	0	1	1	4.280	0.00	0.00	0.3	0.0	10,371.00	3,200.00
38	66100	3	*Course Loop Assy	1	0	1	1	2.400	0.10	0.20	0.5	1.1	3,600.00	1,040.00
39	66110	4	Enclosure, Course Loop	1	0	1	1	0.001	–	–	–	–	400.00	–

*LRU

TABLE 2.2-1. EQUIPMENT ASSEMBLY BREAKDOWN AND LIFE CYCLE COST DATA LISTING
SYSTEM NAME: UAR UNATTENDED SHORT RANGE RADAR, SURVEILLANCE, 2D (Cont'd)

Item No.	Part Number	Ident Lvl	Description	Quantity 3 Mo Active	Quantity 3 Mo Stdby	Quantity 6 Mo Stdby	Quantity 12 Mo Stdby	Failure Rate 10^6	NRTS Rate Node	NRTS Rate Depot	MTTR On Line	MTTR Off Line	Price Data Unit Price	Price Data RPR Cost
40	66120	4	Power Splitter Driver	1	0	1	1	0.200	0.70	0.01	0.0	2.5	1,050.00	75.00
41	66130	4	Loop Filter Assy	1	0	1	1	0.800	1.00	0.80	0.0	2.6	1,030.00	80.00
42	66140	4	Programmable Divider	1	0	1	1	0.800	1.00	0.80	0.0	2.5	1,120.00	90.00
43	66200	3	* Fine Loop Assy	1	0	1	1	2.000	0.10	0.20	0.5	1.1	3,471.00	1,000.00
44	66210	4	Enclosure, Fine Loop	1	0	1	1	0.001	–	–	–	–	400.00	–
45	66220	4	Mixer Assy, Loop	1	0	1	1	0.300	0.20	1.00	0.0	2.5	1,000.00	64.00
46	66230	4	Loop Filter Assy	1	0	1	1	0.800	1.00	0.80	0.0	2.6	995.00	80.00
47	66240	4	Programmable Divider	1	0	1	1	0.800	1.00	0.80	0.0	2.5	1,076.00	90.00
48	66300	3	* Frequency Multiplier	1	0	1	1	2.060	0.40	0.05	0.5	3.5	3,300.00	1,075.00
49	66310	4	Enclosure, Multiplier	1	0	1	1	0.001	–	–	–	–	400.00	–
50	66320	4	Reference Gen	1	0	1	1	0.860	0.20	0.05	0.0	2.5	1,375.00	92.00
51	66330	4	IF Multiplier	1	0	1	1	0.600	0.40	0.05	0.0	3.2	970.00	64.00
52	66340	4	COHO Amplifier	1	0	1	1	0.500	0.50	0.05	0.0	3.4	555.00	53.00
53	66400	2	* Radar Exciter	1	0	0	1	1.682	0.10	0.01	0.3	1.2	5,407.00	1,710.00
54	66410	3	Enclosure Radar Exciter	1	0	0	1	0.001	–	–	–	–	400.00	–
55	66420	3	Pulse Modulator	1	0	0	1	0.500	0.50	0.05	0.0	2.5	1,600.00	42.00
56	66430	3	Chirpline Assy	1	0	0	1	0.500	0.90	0.25	0.0	2.5	1,600.00	42.00
57	66440	3	Mixer - Driver	1	0	0	0	0.582	0.15	0.01	0.0	2.0	1,807.00	120.00
58	67200	2	* IFF Transmitter	1	0	0	0	2.351	0.01	0.01	0.5	1.0	10,888.00	1,130.00
59	67210	3	Enclosure IFF Trans	1	0	0	0	0.076	–	–	–	–	600.00	–
60	67220	3	Amplifier Assy IFF	3	0	0	0	0.729	0.10	0.01	0.0	2.0	850.00	100.00
61	67230	3	Power Divider IFF	1	0	0	0	0.001	1.00	0.10	0.0	1.0	1,750.00	70.00
62	67240	3	Power Combiner IFF	1	0	0	0	0.006	1.00	0.10	0.0	1.0	1,750.00	70.00
63	67250	3	Monitor Assy IFF	1	0	0	0	0.086	0.25	0.05	0.0	1.0	4,238.00	83.00
64	67300	2	* IFF Receiver	1	0	0	1	2.248	0.01	0.00	0.5	1.0	5,157.00	1,400.00
65	67310	3	Enclosure IFF Receiver	1	0	0	1	0.001	–	–	–	–	400.00	–
66	67320	3	Limiter - Filter	1	0	0	1	0.828	1.00	1.00	0.0	0.0	1,700.00	1,700.00
67	67330	3	RF Amplifier - L.O.	1	0	0	1	0.800	0.30	0.05	0.0	3.0	1,640.00	58.00
68	67340	3	AGC - IF Amp	1	0	0	1	0.700	0.20	0.15	0.0	2.5	1,417.00	50.00
69	67400	2	* IFF Exciter	1	0	0	1	0.836	0.10	0.01	0.3	1.2	4,407.00	1,310.00
70	67410	3	Enclosure, IFF Exciter	1	0	0	1	0.001	–	–	–	–	400.00	–
71	67420	3	Pulse Generator	1	0	0	1	0.250	0.05	0.01	0.0	2.5	1,260.00	49.00
72	67430	3	Pulse Modulator	1	0	0	1	0.250	0.30	0.05	0.0	2.5	1,330.00	23.00
73	67440	3	Driver	1	0	0	1	0.236	0.20	0.01	0.0	2.0	1,417.00	54.00
74	68100	2	Radar Signal Processor	1	0	0	0	91.750	0.00	0.00	0.3	0.0	64,587.00	3,260.00
75	68110	3	Enclosure, Wired	1	0	0	0	5.787	–	–	–	–	900.00	–
76	68120	3	* A/D Converter - Encoder	1	0	1	1	3,438	0.40	0.25	0.3	3.0	4,820.00	253.00
77	68130	3	* Central Timing Unit	1	1	1	1	3.976	0.30	0.01	0.2	2.0	1,930.00	20.00
78	68140	3	* Control/Mon - Proc Interface	1	1	1	1	5.476	0.20	0.05	0.2	2.5	3,040.00	32.00

*LRU

TABLE 2.2-1. EQUIPMENT ASSEMBLY BREAKDOWN AND LIFE CYCLE COST DATA LISTING
SYSTEM NAME: UAR UNATTENDED SHORT RANGE RADAR, SURVEILLANCE, 2D (Cont'd)

Item No.	Part Number	Ident Lvl	Description	Quantity 3 Mo Active	Quantity 3 Mo Stdby	Quantity 6 Mo Stdby	Quantity 12 Mo Stdby	Failure Rate 10^6	NRTS Rate Node	NRTS Rate Depot	MTTR On Line	MTTR Off Line	Price Data Unit Price	Price Data RPR Cost
79	68150	3	* Comm Interface Unit	1	1	1	1	4.419	0.05	0.01	0.2	2.6	3,225.00	34.00
80	68160	3	* Doppler CFAR Processor	8	1	2	3	6.344	0.10	0.01	0.2	2.1	4,630.00	49.00
81	68170	3	* Clutter Map Assy	2	2	2	2	3.773	0.10	0.01	0.2	2.0	2,760.00	29.00
82	68180	3	* Correlation Detector	1	1	1	1	2.910	0.10	0.01	0.2	2.0	2,120.00	22.00
83	68190	3	* IFF Target Det Unit	1	0	0	1	3.342	0.15	0.01	0.2	2.0	2,430.00	26.00
34	68191	3	* IFF Target Buffer	1	0	0	1	3.442	0.15	0.01	0.2	2.0	2,510.00	26.00
85	68192	3	* Jamming Detector	1	0	0	1	0.662	0.10	0.01	0.2	1.5	1,052.00	11.00
86	68200	2	Data Processor	1	0	0	0	111.208	0.00	0.00	0.3	0.0	17,075.00	1,100.00
87	68210	3	Enclosure Wired	1	0	0	0	3.680	–	–	–	–	800.00	–
88	68220	3	* CPU Module No. 1	1	1	2	2	16.000	0.25	0.10	0.5	4.2	1,025.00	25.00
89	68230	3	* CPU Module No. 2	1	1	2	2	16.000	0.25	0.10	0.5	4.2	1,200.00	25.00
90	68240	3	* CPU Module No. 3	1	1	2	2	15.000	0.25	0.10	0.5	4.2	850.00	25.00
91	68250	3	* Programmed Memory Assy	4	4	4	4	6.464	0.10	0.01	0.5	3.0	1,500.00	15.00
92	68260	3	* Working Memory Assy	4	2	2	4	8.839	0.05	0.01	0.5	3.0	1,800.00	18.00
93	69000	2	Power Supply GP	1	1	1	1	0.532	0.00	0.00	0.6	0.0	16,513.00	7,200.00
94	69100	3	Inverter - Regulator	1	1	1	1	0.325	0.20	0.02	0.5	1.5	9,013.00	90.00
95	69110	4	Transformer	4	4	4	4	0.007	1.00	1.00	0.0	0.5	1,750.00	1,750.00
96	69120	4	* Rectifier Assy	1	1	1	1	0.160	0.05	0.01	0.0	0.8	2,013.00	42.00
97	69200	3	* Regulator Assy, L.V.	15	15	15	15	0.101	0.15	0.05	0.5	1.1	500.00	9.00

*LRU

Each node will be a self-contained facility capable of supporting a permanently manned maintenance and supply environment. The following node assignments have been made:

Node Designator	Node Location	Number of Sites Supported		Mean Travel Time To Site
N1	Point Barrow	14		1.27
N2	Tuktoyaktuk	14		1.4
N3	Cambridge Bay	13		1.3
N4	Hall Beach	11		1.15
N5	Point Dyer	11		1.2
N6	Saglek (New Site)	8		0.96
N7	Goose Bay	9		1.26
7		80	System Mean	1.21

Generally, nodes are centrally located in the cluster of operational sites they serve. The average distance between stations is less than 50 nmi and the maximum distance from node to an operating site is 350 nmi. Helicopters, the prime means of node-to-site transportation, are assumed to have an operational range of approximately 500 nmi. UAR depot repair actions will be performed at existing facilities at McClellan Air For Base.

2.3.1 On-Site Maintenance

Demands for maintenance action will be initiated by on-line, built-in-test-equipment (BITE) and reported through the communications link to the node. At this time a maintenance team of two intermediate level electronic technicians and a power equipment technician will travel by helicopter to the site. A complete complement of line replaceable unit (LRU) spares and assorted discrete parts will be stowed on the helicopter for use on site as required. The helicopter will also contain a complete set of common test equipment and tools necessary to perform organizational maintenance. No tools, test equipment or spares will be stored on-site.

The fault isolation process involves use of the on-line BITE system. The BITE design objectives are compatible with LRU packaging which is to isolate 95 percent or more of all system failures to an LRU module(s) concept. These objectives are:

- System level BITE to report system performance status
- Subsystem level BITE to detect a fault in a primary equipment element and to activate switching to backup equipments.
- BITE penetration to a single LRU for 95 percent of all system failures
- Maximum BITE penetration within each LRU to the shop replaceable unit (SRU) level to assist off-line repair activity.

At arrival on-site, the electronic technician(s) will check the subsystem status indicators and replace defective LRU's. All individual subsystem tests will be activated to determine the need to replace other LRU's which failed since the last visit causing a "failed item" report but which, because of redundancies, did not result in a "failed system" maintenance demand.

Before departing the site, technician(s) will perform all preventive maintenance (PM) normally scheduled for the near term to eliminate the need for the next scheduled visit if possible. The waveguide drier (desiccant) elements will be replaced at six-month intervals or during unscheduled visits.

2.3.2 Node Maintenance

All defective LRU's for a given complex of sites will be evacuated to the node for repair, disposal, or further evacuation to the depot. Each node serves as a repair and supply support center and will be fully equipped to perform those functions. A two-year supply of LRU's/SRU's and repair parts will be stocked at each node to support its complex of sites. The repair facility consists of a bench environment and will be equipped with tools, test equipment and test fixtures necessary to test and repair the LRU's.

2.3.3 Depot Maintenance

LRU's/SRU's not repairable at the node will be returned to the depot for repair or disposal. The recommended UAR places no special demands on the depot. Special tools and test equipment will be CFE furnished.

2.3.4 Maintenance and Support Manning

Nodes N1 and N2 which have the largest number of satellites, will each support 14 operating sites. Based on system failure rates and standard Poisson distribution (see Figure 2.3-1), the number of yearly demands from 14 operating sites will be less than one-per-month for the three-month reliability configurations. This low demand rate and a PM schedule having a minimum three-month interval indicates that a single maintenance team can easily perform all on-site and node maintenance tasks. The extremely low statistical probability of simultaneous failure of two UARs further supports the single team concept.

A three-man node electronics team is recommended. Two men would travel to the sites when needed to perform maintenance. The third man would remain at the node to monitor the status of the remaining operating systems. A three-man team provides its own back-up in event of illness.

Electronic technicians will have LRU repair skills involving the use of bench environments and hand tools as well as the system skills necessary to accomplish on-site maintenance for all electronic equipments.

Power equipment will be maintained by a power equipment specialist assigned to the node maintenance team.

2.4 Equipment Installation

Installation of UAR equipment is complicated by the number of sites involved and the hostile environmental conditions that prevail in the Arctic. With a time window of only

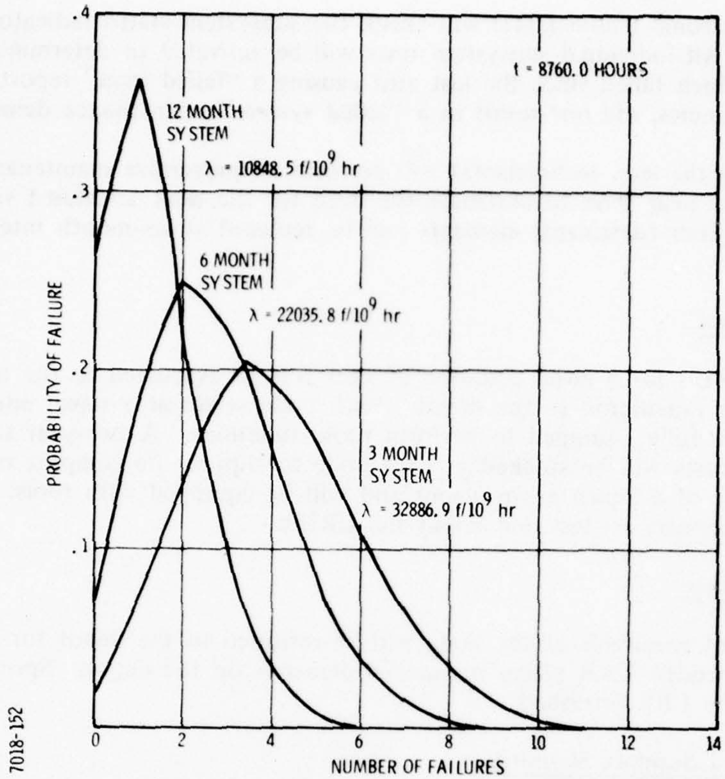

Figure 2.3-1. Failure Probabilities

24 months in which to accomplish this task, a great deal of emphasis will be placed on developing an installation plan compatible with program requirements and schedules. A preliminary schedule is described in Figure 2.4-1.

2.4.1 Installation Planning

The installation plan has been segregated into smaller planning elements to provide greater cost and schedule visibility. Costs associated with installation elements are contained in Paragraph 2.6. A final plan will be developed early in the RDT&E program that includes customer recommendations and guidance.

2.4.2 UAR Installation Sequence and Schedule

The UAR site installation sequence is based upon the following assumed conditions:

a. The towers and other structures to support the antennas and other radar equipment are completed and in place.

b. Each tower will be able to support and provide mounting interfaces for a lightweight modularized crane.

c. Prime power sources and distribution systems will be available to support installation activities.

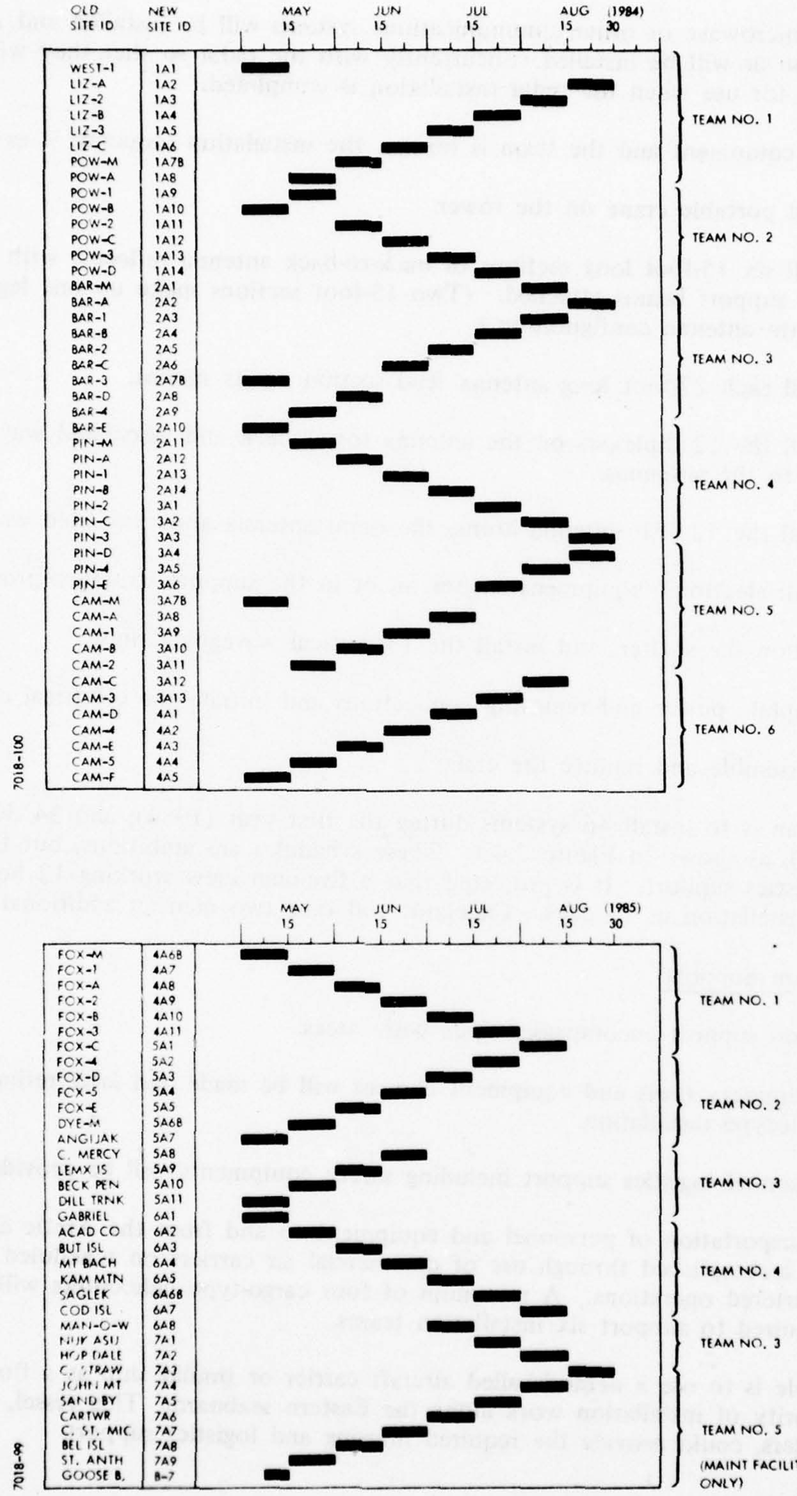

Figure 2.4-1. Installation Schedule

d. The microwave or other communications systems will be installed and ready for use or will be installed concurrently with the radar so that they will be ready for use when the radar installation is completed.

When the equipment and the team is on-site, the installation sequence is as follows:

a. In[illegible] portable crane on the tower.

b. Install six 15-foot long sections of back-to-back antenna reflector with feed array support beams attached. (Two 15-foot sections make up one leg of the tri-form antenna configuration.)

c. Install each 27-foot long antenna feed section on its mount.

d. Install the 12 diplexers on the antenna tower deck and associated waveguide runs to the antennas.

e. Install the 12 IFF antenna horns, the omni antenna and associated waveguide.

f. Install electronic equipment shelter on or in the support structure provided.

g. Position the shelter, and install the 13 vertical waveguide runs.

h. Complete power and remoting connections and initiate the electrical checkout.

i. Disassemble and remove the crane.

The preliminary plan is to install 46 systems during the first year (1984), and 34 during the second year (1985), as shown in Figure 2.4-1. These schedules are ambitious, but feasible with sufficient logistics support. It is projected that a five-man crew working 12 hours a day can complete an installation in 15 days. Checkout will take two men an additional five days.

2.4.3 Installation Support

Installation support encompasses three basic areas:

a. Preliminary tools and equipment choices will be made and later refined during prototype installation.

b. Personnel logistics support including safety equipments will be provided.

c. Transportation of personnel and equipment to and from the Arctic areas will be accomplished through use of commercial air carriers on scheduled or chartered operations. A minimum of four cargo-type helicopters will be required to support six installation teams.

An option available is to use a demothballed aircraft carrier or similar ship as a floating support base for the majority of installation work along the Eastern seaboard. This vessel, equipped with two helicopters, could provide the required housing and logistics support.

2.5 LRU Stockage Model

The initial and recurring investment in LRU's is a logistics LCC element. The selection and allocation of main spare units was accomplished using math models to optimize the dollars invested to achieve an operational availability (A_{op}) ≥ 90 percent. Three models were used in the optimization process.

- OPSTOCK – Optimum Stockage for multilevel maintenance environment. Optimization based on risk for spares shortage vs operational availability
- CONSUME – Consumable item requirement based on stockage objectives and support pipelines
- Q-FACTOR – A subroutine based on maintenance and logistic time distributions which establishes a risk for spares factor.

2.5.1 Support Variations

The math models accommodate variations in the number of sites supported by each node and provide separate printed stockage lists for each node. The models also consider depot turn-around time and the need to fill the pipelines. Identical kits of on-board spares for the node helicopters has been assumed.

The models determine stockage requirements on basis of the detailed LRU data described in Paragraph 2.2.2. Not-repairable-this-station (NRTS) rates for the node and depot have also been assigned which influence stockage quantities and account for attrition of the most vulnerable items.

2.5.2 Initial Spares

The cost of initial spares, repairables and consumables, is based on the Operational Availability (A_{op}) objective. Assuming a risk for shortage of 0.25 (see Paragraph 2.1.2) for a 3-month configuration, the cost of initial spares can be determined using the graph in Figure 2.5-1. A 0.25 risk translates to an LRU investment of approximately 470,000.00 dollars. A 6-month configuration with the same A_{op} objective would require a 220,000.00 dollar investment.

Figure 2.5-1 indicates the dollar amount and the computer program prints a corresponding list of LRUs. For a two-year stockage objective this initial spares dollar amount is added to the cost of consumables expended in two years as determined by the CONSUME model.

2.6 Life Cycle Cost Computation

All LCC dollar amounts shown are in constant January 1977 dollars without discounting. Prices used in these computations are based on an 80 system build, with a concurrent build of all spares for the life cycle. Common test equipment cost computations were based on current catalog prices.

The system contains a single life limited item, the waveguide desiccant elements, and the demands for this item were processed at the replacement rate. All other items were processed at the failure rate. Redundant systems were assumed to be in "cold" standby.

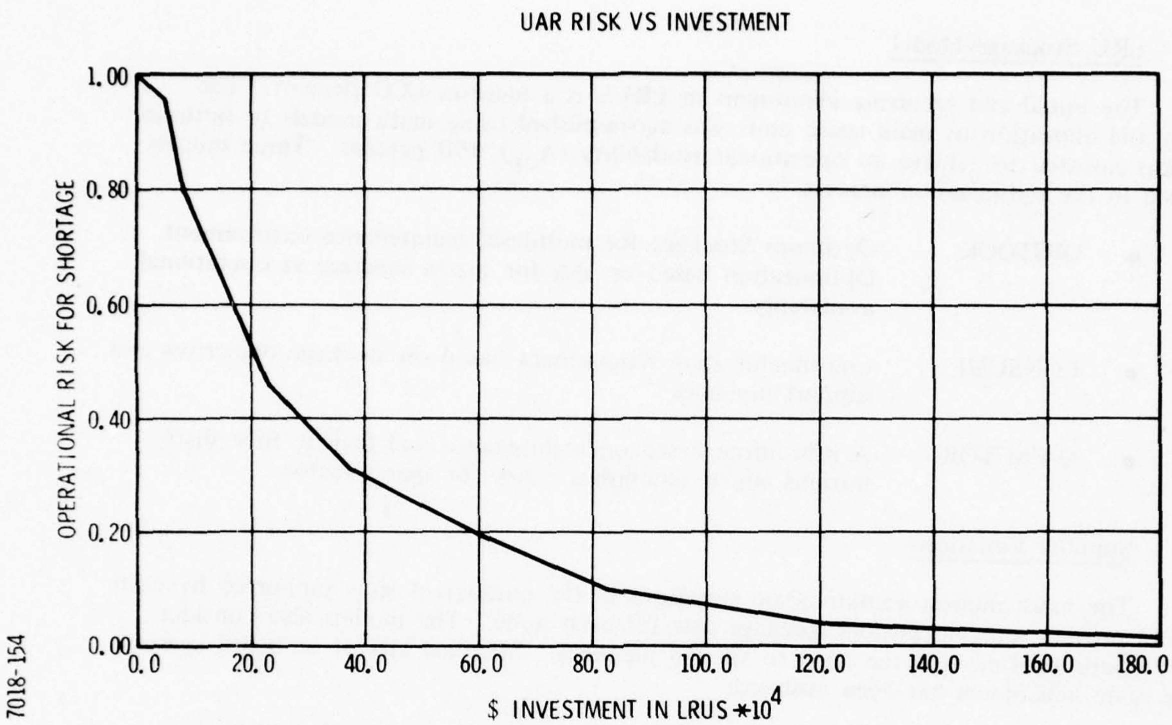

Figure 2.5-1. UAR Risk versus Investment

All support calculations were based on all systems operating in a full performance mode, full time for the life cycle.

2.6.1 Life Cycle Cost Summary

This summary includes three equipment options and two node manning options. The data is presented in matrix format in Table 2.6-1.

2.6.2 Acquisition Costs

The RCA PRICE model was used to obtain acquisition cost data for the UAR. This is a parametric cost modeling technique that provides reliable estimates of system acquisition costs especially during the conceptual phase of a program. PRICE inputs are primarily physical characteristics such as size, weight, type of componetry, power dissipation, and construction type. Prototype and production quantities are also required inputs. PRICE model outputs include recurring and nonrecurring costs for development and production phases. It also provides an engineering schedule, and it has numerous internal checks to verify reasonableness of the various results.

Printouts from the UAR PRICE Model are given in Appendix A. Greatest accuracy is obtained from the model when a system is broken down into small constituent parts. In addition, purchased items are handled most effectively by being considered separately. This was done in the UAR modeling with the receiver, exciter, and synthesizer purchase parts lumped into a single purchased item. As a consequence, it is difficult to determine the total

TABLE 2.6-1. LIFE CYCLE COST SUMMARY MATRIX

LCC Cost Category	3-Month Configuration USAF Technicians	3-Month Configuration Contractor Technicians	6-Month Configuration USAF Technicians	6-Month Configuration Contractor Technicians	12-Month Configuration USAF Technicians	12-Month Configuration Contractor Technicians
Acquisition Cost	51,124,952.00	51,124,952.00	54,058,768.00	54,058,768.00	59,283,659.00	59,283,659.00
Initial Logistics	17,306,806.00	17,924,862.00	16,956,806.00	17,674,862.00	16,736,806.00	17,454,862.00
Recurring Logistics x 18 Yrs	12,627,144.00	23,595,912.00	12,627,144.00	23,595,912.00	12,627,144.00	23,595,912.00
Totals	$80,958,902.00	92,645,726.00	$83,642,718.00	$95,329,542.00	$88,647,609.00	$100,334,433.00

costs of these individual items from the printouts. Table 2.6-2 gives the cost breakdown of the units with the appropriate purchase item cost added to the PRICE estimate of the unit.

The baseline system is the minimum system capable of performing required radar operations. It contains no redundancy other than that inherent in designs of the individual modules. The platform factor (PLATFM) of 1.95 used for the PRICE runs implies a very high reliability design, using components that roughly satisfy the reliability requirements discussed in Volume II. In order to meet the 3-, 6-, and 12-month reliability goals, module redundancy is also needed. The required redundancy for these three cases and their cost impacts are given in Tables 2.6-3 through 2.6-5. In each case, the needed redundancy is specified relative to the baseline system. Also, an additional 15 percent of the cost of redundant items is added to the total to account for increased switching and other miscellaneous equipment that may be required.

TABLE 2.6-2. BASELINE UAR PRICE BREAKDOWN ($K)

	Development	*Production*	*Total Cost*	*Avg Prod Cost/Unit*
RF Receiver (2 Req'd)	632	800	1432	4.994
IF Receiver	338	419	757	5.232
Radar Exciter	178	432	610	5.407
IFF Receiver	254	413	667	5.157
IFF Exciter	178	353	531	4.407
Synthesizer	440	830	1270	10.371
Signal Processor	4171	5167	9337	64.588
Power Supplies	1020	1177	2197	14.713
Radar Transmitter	1821	4365	6186	54.563
IFF Transmitter	660	871	1531	10.888
Waveuigde Switch	667	727	1394	9.088
Waveguide	63	2538	2601	31.725
Antenna	2053	10930	12984	136.625
Data Processor	34	1366	1401	17.075
Integration and Test	348	1357	1705	16.963
Total Baseline	12859	31744	44603	396.800

There are several points which should be mentioned in regards to these data. The cost figures given are factory cost and are not the actual sell price of the equipment. Also, these are radar costs only, and they do not include costs of communication equipment, shelter, prime power, environmental control equipment, or purchase and installation of the antenna tower. In addition, the costs related to a Reliability Verification and Modification Program during and after system deployment are not included. It is impossible at this time

TABLE 2.6-3. UAR THREE-MONTH CONFIGURATION

Redundant Items	
1 Central Timing Unit	$ 1,930
1 Control Monitor/Proc. Interface	3,040
1 Communication Interface	3,225
1 Doppler CFAR Proc.	4,630
2 Clutter Maps	5,520
1 Correlation Detector	2,120
1 CPU Assembly	3,875
4 PROM Boards	6,000
2 RAM Boards	3,600
1 Power Supply	16,513
Cost of Redundant Items	50,453
15% of Cost for Switching and Misc.	7,568
Total for Redundancy	58,021
Baseline	396,800
Total for 3 Mo. Configuration	$454,821
System Acquisition Costs (80 Units)	
Development	$14,739,272
Production	36,385,680
Total	$51,124,952

TABLE 2.6-4. UAR SIX-MONTH CONFIGURATION

Redundant Items	
1 Central Timing Unit	$ 1,930
1 Control Monitor/Proc. Interface	3,040
1 Communication Interface	3,225
2 Doppler CFAR Proc.	8,260
2 Clutter Maps	5,520
1 Correlation Detector	2,120
2 CPU Assemblies	7,750
4 PROM Boards	6,000
2 RAM Boards	3,600
1 Power Supply	16,513
1 Frequency Synthesizer	10,371
1 A/D Converter	4,820
Cost of Redundant Items	73,149
15% of Cost for Switching and Misc.	10,972
Total for Redundancy	84,121
Baseline	396,800
Total for 6 Mo. Configuration	480,921
System Acquisition Costs (80 Units)	
Development	$15,585,088
Production	38,473,680
Total	$54,058,768

TABLE 2.6-5. UAR TWELVE-MONTH CONFIGURATION

Redundant Items	
1 Central Timing Unit	$ 1,930
1 Control Monitor/Proc. Interface	3,040
1 Communication Interface	3,225
3 Doppler CFAR Proc.	13,890
2 Clutter Maps	5,520
1 Correlation Detector	2,120
2 CPU Assemblies	7,750
4 PROM Boards	6,000
4 RAM Boards	7,200
1 Power Supply	16,513
1 Frequency Synthesizer	10,371
1 A/D Converter	4,820
1 Radar RCVR, RF	4,994
1 Radar RCVR, IF	5,232
1 Radar Exciter	5,407
1 IFF Receiver	5,157
1 IFF Exciter	4,407
1 IFF Target Detection Unit	2,430
1 IFF Buffer	2,510
1 Jamming Detector	1,052
Cost of Redundant Items	113,568
15% of Cost for Switching and Misc.	17,035
Total for Redundancy	130,603
Baseline	396,800
Total for 12 Mo. Configuration	$527,403
System Acquisition Costs (80 Units)	
Development	$17,091,419
Production	42,192,240
Total	$59,283,659

to evaluate the extent of such a program; however, it is almost inevitable that design changes will be required in order to meet the reliability requirements. Depending on the deployment schedule, the reliability confidence level desired, and amount of redesign required, a possible increase in the system acquisition cost by 25 percent seems reasonable.

2.6.3 Initial Logistic Cost

The cost elements directly related to the initial deployment of 80 UAR systems are:

2.6.3.1 Spares (24-Month)

Spares (24-Month)	3-Month	6-Month	12-Month
LRU/SRU (Node & Depot)	$482,870.00	$232,870.00	$12,870.00
Repair Parts	36,496.00	36,496.00	36,496.00
Total	$519,366.00	$269,366.00	$49,366.00

Initial quantities of LRU/SRU spares was determined by the OPSTOCK computer model. LRU/SRU repair parts were determined by a maintenance demand calculation and summed with a percent allocation for other piece-parts.

2.6.3.2 Inventory Entry (Codification)

LRU/SRUs (66 Line Items)	$ 6,600.00	
Nonstandard Parts (750 Estimated)	75,000.00	
Total		$81,600.00

Inventory entry was calculated at $100.00/item.

2.6.3.3 Personnel (Node)

USAF Electronic Technicians (24 Men)	$414,000.00
or	
Contractor Electronic Technicians (24 Men)	$1,154,400.00

USAF Technicians are in the E4-E6 pay and allowance categories ($525.00/mo. + $30.00/day)

Contractor Technicians calculations includes base pay, allowances and contractor support & transportation.

A 56-hour work week is assumed.

2.6.3.4 Training (2 each, 14 week Courses-Contractor Training)

Training Data, Instruction, Facilities	$256,000.00
USAF Technician Pay & Allowances (24 Men)	135,240.00
Total	$391,240.00
or	
Training Data, Instruction, Facilities	$256,000.00
Contractor Technicians (24 Men)	112,896.00
Total	$368,896.00

Contractor technicians are not paid allowances during training. Attrition of 3-men prior to or during assignment is assumed.

2.6.3.5 Tools and Test Equipment

Common Tools at Nodes (7 nodes)	$479,000.00	
Test Equipment (7 nodes)	630,000.00	
Common Tools at Depot	7,300.00	
Test Equipment & Fixtures, Depot	85,700.00	
Total		$1,202,000.00

Node quantities include helicopter kits.

2.6.3.6 Technical Documentation (TOs)

Preparation and 100 sets	$600,000.00

Consists of Operations, Service, Operation, IPB To USAF Standards

2.6.3.7 Installation and Checkout (80 Systems)

Labor	$2,114,400.00	
Special Tools & Installation Equipt.	1,280,000.00	
Personnel Logistics	610,000.00	
Transportation (Installation & Personnel)	2,636,200.00	
Transportation of Radar Sets	7,358,000.00	
Total		$13,998,600.00

Eighty (80) sets, each having 10,875 cubic feet & weighs 16,200 lbs (does not include spares or test equipment). Six Contractor teams will perform the installation.

2.6.3.8 Total of All Initial Logistics Costs

	3-Month	6-Month	12-Month
All Items & USAF Tech. Option	17,206,806.00	16,956,806.00	16,736,806.00
All Items & CTS Option	17,924,862.00	17,674,862.00	17,454,862.00

2.6.4 Recurring Logistic Cost

The cost elements directly related to sustaining operational performance of UAR systems on an annual basis are:

2.6.4.1 Spares Replenishment

LRU/SRUs (Node & Depot)	$ 6,435.00	
Repair Parts (Node & Depot)	18,248.00	
Total		$24,863.00

LRU/SRU quantities were determined by the CONSUME computer model. LRU/SRU repair parts were determined by a maintenance demand calculation and summed with a percent allocation for other piece-parts.

2.6.4.2 Inventory Management

LRU/SRU (66-Line Items)	$ 6,600.00	
Nonstandard Parts (750 Estimated)	75,000.00	
Total		$81,600.00

Inventory Management calculated at $100.00/Item/Year

2.6.4.3 Personnel (Node)

USAF Electronic Technicians (24 Men)	$414,000.00
or	
Contractor Electronic Technician (20 Men)	$962,000.00

Refer to Item 1.6.3.3 for rates
Contractor technician attrition is ≅ 83 percent.

2.6.4.4 Training (2 each, 14-week Courses – USAF Training)

Training Equipment & Support	$23,553.00	
Training Instructors USAF (4 Men*)	7,360.00	
USAF Technician Pay & Advances (24 Men)	44,160.00	
Total		$75,073.00

*E4-E6 Rate

or

Training Equipment & Support	23,553.00	
Contractor Training (20 Men)	112,896.00	
Total		$136,449.00

A training system should be procured: Training equipment calculated at 1/20 of acquisition cost. Support cost based on 16 hours per day equipment utilization. Training set, of contractors site, is "bailed" equipment. Contractor training of 20 men includes four instructors.

2.6.4.5 Depot Maintenance

Manhours	$ 1,148.00

Maintenance calculated at $20/manhour

2.6.4.6 Maintenance Administration

Depot	$ 7,174.00

Maintenance Administration calculated at $250.00/repair action at depot.

2.6.4.7 Tools and Test Equipment Maintenance

Nodes and Depot	$35,250.00

Maintenance cost calculated at 5 percent of acquisition cost/year.

2.6.4.8 Preventive Maintenance (Materials)

On Site (80 sites)	$62,400.00

2.6.4.9 Total of All Recurring Logistics Costs (Annual)

All Items and U.S.A.F. Technician and Training	$701,508.00
or	
All Items and Contractor Technicians and Training	$1,310,884.00

3.0 MAR LIFE CYCLE (LCC) COSTS

Two of the three factors in the LCC algorithm are logistics dependent, e.g.,

$$LCC = A_T + I_L + \sum_{i=1}^{N} R_L$$

where

A_T = acquisition cost total

I_L = initial logistics cost

R_L = recurring logistics cost (annual)

N = number of years in the life cycle.

In order to quantify these logistics factors, a specific systems deployment and maintenance philosophy must be defined. Such a plan has not been developed for MAR, consequently its LCC cannot presently be determined. An estimate of MAR's acquisition cost, however, has been made based on a production run of 20 systems. Furthermore, certain aspects of a suggested maintenance philosophy, based on achieving a low LCC, have been addressed.

The acquisition cost of MAR is estimated as follows:

Average unit cost based on a quantity of 20 units = \$2,110K
(for the 5-day reliability configuration)

The acquisition cost total = 20 x \$2,110K = \$42.2M

The maintenance philosophy suggested is presented in the following paragraphs.

3.1 MAR Maintenance Philosophy

3.1.1 Maintenance Structure

Based on MAR architecture, BITE penetration, (number of systems involved), and assuming full-time operation (168 hours per week) a two-tier maintenance structure is recommended: these two levels are the organizational level (on-site) and the depot level.

Investigations, involving life-cycle cost (LCC) analyses, indicate that consolidation of the first three echelons of repair at the organizational level is a viable cost-effective option. On-site maintenance of certain LRU repairables that involve removal and replacement of low-cost consumable materials is recommended, instead of a flow of these repairables through a repair loop. All LRU's will be individually considered to determine how they best "fit" into stockage and repair aspects of the maintenance system.

3.1.2 Organizational Maintenance

All organizational maintenance can be performed by a single trained technician. Certain maintenance activities may require more than one man because of safety or physical

size/weight of an item involved in the maintenance action. However, this assistance to the technician does not require any system skills. The on-site maintenance will be an intermediate level technician (USAF Level 5) with certain bench skills involving use of soldering tools and standard test equipment. The on-site technician will be responsible for all preventive maintenance, corrective maintenance, certain LRU repairs, and performance testing of the system subsequent to any corrective maintenance actions or modification of equipment.

a. Preventive maintenance (PM) – The off-line radar preventive maintenance intervals are greater than 168 hours. This preventive maintenance (PM) features is in keeping with an operational availability objective exceeding 90 percent for one week of continuous operation. A small amount of daily on-line PM consisting primarily of monitoring BITE indicators or metering devices is recommended.

b. Corrective Maintenance (CM) – The BITE minimizes skill requirements, need for special purpose test equipment on-site, and reduces the requirement for standard test equipments.

All faulty digital modules and digital portions of the hybrid modules used throughout the MAR are repaired on-site to the maximum extent feasible. Each site is furnished a digital test set to facilitate rapid identification of failed integrated circuit devices. The on-site technicians remove and replace defective items using repair materials from on-site stock. Certain repairable analog-type LRU's used in the transmitter are repaired on-site when possible.

LRU's in antenna or transmitter high-voltage areas which cannot be safely repaired and tested on-site are evacuated to the depot facility. Analog modules of the receiver are repaired at the depot where the required analog test station and test fixtures are available. All electro-mechanical LRU's removed from major subsystems are returned to depot facility for repair and subsequent testing.

3.1.3 Depot Maintenance

The prime responsibility of the depot is to provide operating units with a constant source of equipment spares. The depot meets this responsibility by maintaining stockage quantities which meet all demands and fill all pipelines to the operating satellites. To perform this function in a cost-effective manner, the depot is fully equipped and manned to effect repair of items returned from the field. Pipeline time between the depot and operating sites is a factor in determining spares requirements.

The depot is equipped with a digital dual disc base console to facilitate repair of all digital modules used in the radar. This test console provides the depot facility with the backup capability of fault isolating and repairing all digital modules. The digital test console at the depot also serves to support the portable digital tester used at the sites.

The analog test station includes a complement of interfacing test fixtures necessary to facilitate fault isolating, alignment, and testing of all analog modules. Those test fixtures required to fault isolate, align, and test modules in the transmitter high voltage area, which cannot be tested safely on-site, are available at the depot.

3.1.4 Maintenance Manning

On-site maintenance, including repair of certain modules, can be accomplished by one man per maintenance shift. Assuming full-time operations of 168 hours per week, the work week could be divided into three, 56-hour shifts which would indicate the need for three technicians.

However, high system reliability results in few maintenance demands for both on-line and off-line actions, and the total "downtime" due to preventive maintenance is less than 25 hours per year.

Based on those system maintenance requirements and the remote status/alarm system (reference BITE, paragraph 2-2) the equipment does not require a man in constant attendance. A technician must be on-call however, and the distance between the radar set and standby area should be compatible with the 0.5 hour MTTR objective. If this condition is satisfied, a single, standard, 40-hour maintenance shift is recommended during which scheduled daily PM and other nonscheduled PM is performed and all bench repair activities accomplished. The work schedule could consist of one standard 40-hour maintenance shift and a "standby" maintenance shift for the remaining time.

Recommended MAR Site manning is: 2 men, AFSC 5. With modernization of the Dew Line installations, the USAF has an option open to them that could reduce their electronic maintenance manpower costs by as much as 25 percent. The maintainability and packaging design of all new equipment is rapidly reducing the technicians' requirement for higher levels of system knowledge. Under the LRU remove and replacement concept, a technician need only be capable of interpreting the system BITE indications. Therefore, by cross-training electronic technicians, further manpower reductions can be realized.

3.2 BUILT-IN TEST EQUIPMENT (BITE) CONCEPT (Figure 3.2-1.)

The MAR BITE design is basically a two-tier system that is automatic and on-line. The first tier collects status information from the subsystems, relays it to a remote center and displays it on the local maintenance console control and status panel.

The second-tier monitors all critical subsystem parameters, reports to the first tier and displays the information on local equipment group panels.

3.2.1 BITE Objectives

The BITE penetration design objectives are to isolate faults to:

- A single LRU, on-line, for 75 percent of system failures
- Three LRU's, on-line, for 90 percent of system failures
- A single LRU, off-line, for 95 percent of system failures.

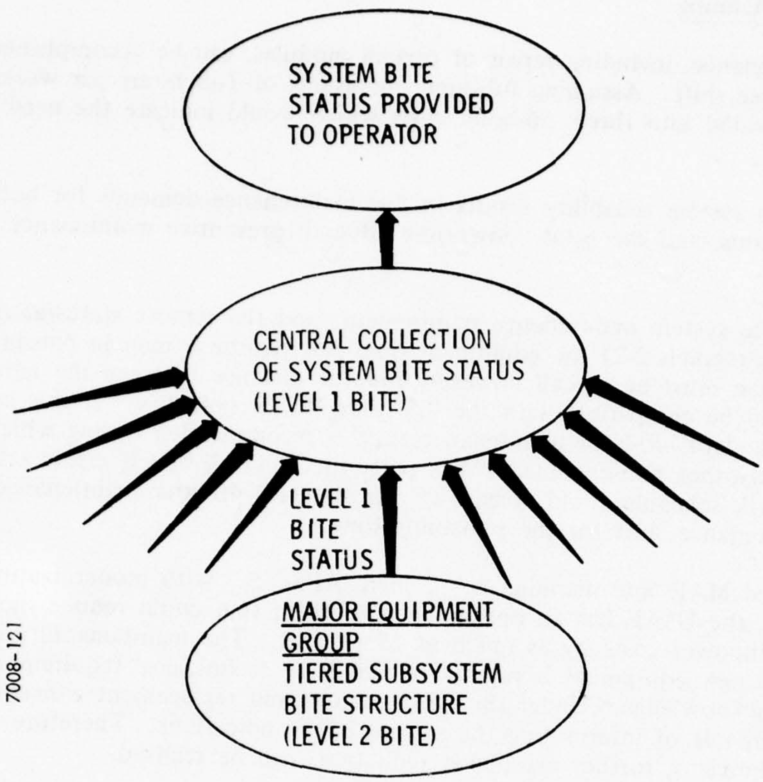

Figure 3.2-1. General BITE Concept

3.2.2 System Status Panels

The system status panels will use green, amber, and red indicators for the following conditions:

- Green = Status Satisfactory
- Amber = Subsystem in Maintenance Mode
  or
  Subsystem Requires Maintenance
- Red = Status Unsatisfactory.

If the system includes backup equipment, each channel will have a separate set of indicators. Should a fault occur, the BITE system will initiate an automatic switch-over sequence to the standby channel. The indicators will show which channel is on-line.

Status of the following equipment groups will be shown on the system status panel: Antenna, Receiver/Synthesizer/Processor, Transmitter, and IFF.

3.2.3 Subsystem Status Panel

Each subsystem will have a local second-tier BITE status panel. The antenna, because it is physically separated from the remaining equipment will have its status remoted to the receiver/processor panel.

The Receiver/Synthesizer/Processor panel (Figure 3.2-2) is a sample of an equipment group panel. As an example, consider the following:

1. A fault in the RCVR/SYNTH/PROC group is reported on the system status panel.

2. The technician checks the local panel and observes that FAULT 2 SYN A is illuminated.

3. Using the thumbwheel selector, he sets the fault code to 02.

4. The ENTER/SEQUENCE switch is activated and the LRU designator appears.

5. If the sequence involved two or more LRU's, the multiple fault indicator would be illuminated. The LRU with the highest probability of failure would appear in the FAULT REF DESIG window.

6. Depressing the sequence switch would enter the next LRU designator.

This sequence is summarized in Figure 3.2-3.

3.2.4 Display Console

The Maintenance Display Console is provided for the purpose of monitoring MAR's output target message data quality. The display is not considered mission essential hardware. In the event of a remoting system malfunction, the display will assist in the fault isolation process.

3.3 Supportability

Support cost could be a significant element in the life cycle cost for the MAR. These costs, which are a consequence of design, can be determined for a given equipment assessed in a given operational environment and when taken cumulatively, define the supportability characteristic of the design. To quantify this characteristic, however, requires considerable customer and contractor data not presently available in the form necessary to complete this study.

Supportability can also be measured in less specific terms by evaluating various aspects of design and their logistic effect. In following paragraphs, the consequence of our selected MAR design approach have been summarized in supportability terms.

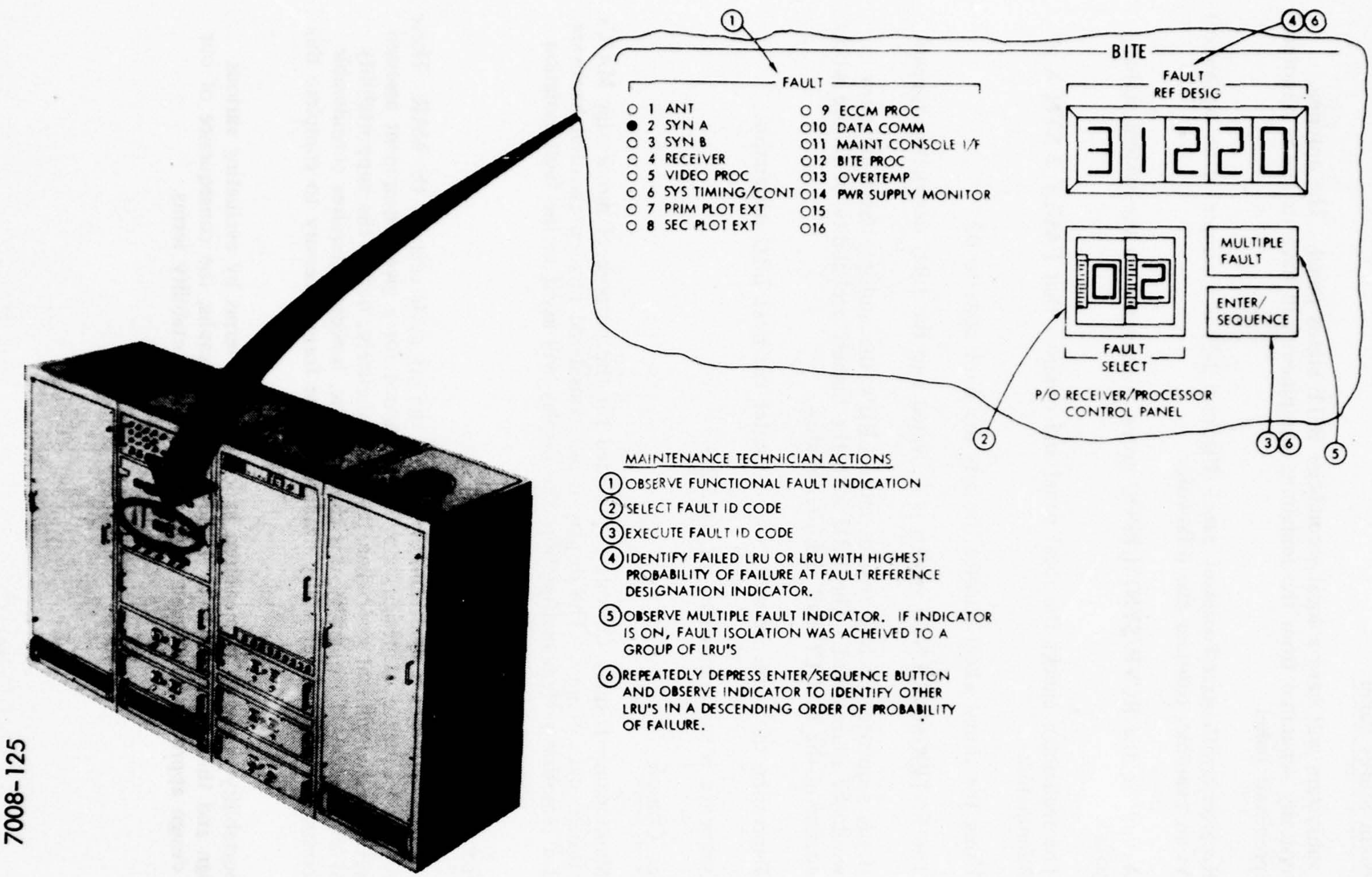

Figure 3.2-2. Fault Isolation Example

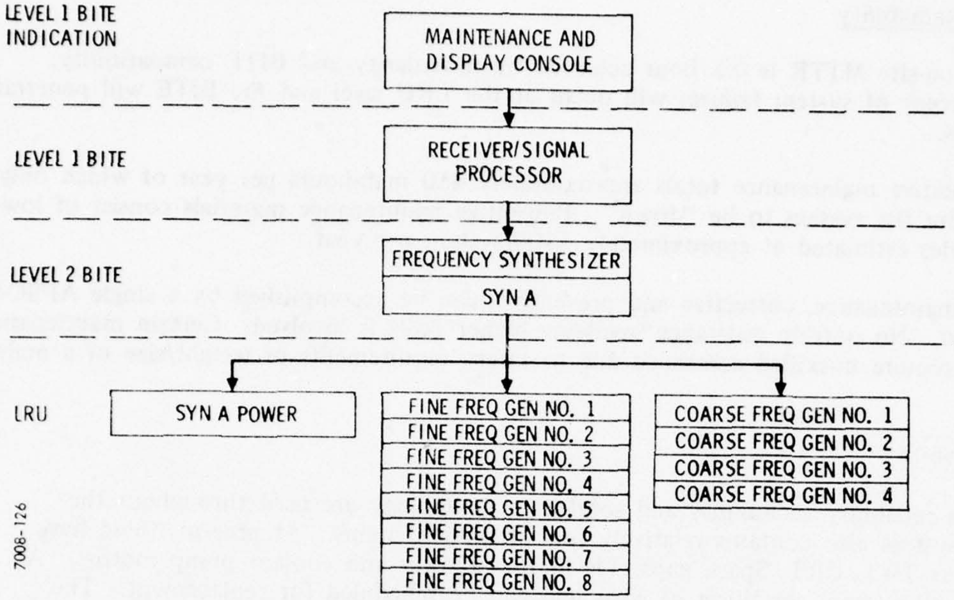

Figure 3.2-3. Fault Isolation Example Summary

3.3.1 Modularity

The MAR baseline maintenance design involves modular packaging of the equipment to facilitate removal and replacement maintenance on-site. The radar set will consist of approximately 200 LRU's. These 200 LRU's will represent 95 percent or more of the systems failure rate.

3.3.2 Commonality

All like items will be directly interchangeable. Where possible, common solutions will be used to reduce the number of different items. The processor for example, will contain approximately 60 boards of five different types. Power supply commonality has been achieved by using the best tolerance, regulation, or capacity where common voltages are required. Blower motor commonality is achieved in the same manner. There are approximately 160 different LRU types in the radar set.

3.3.3 Repairability

Approximately 75 to 78 percent of all failures on site will be corrected without involving the depot. This is achieved through a combination of on-site repair of digital LRU's and discard of consumables on failure. Twenty-two to twenty-five percent of system failures involve electronic LRU, and three percent of less are mechanical item failures. These LRU's will be repaired at depot.

3.3.4 Maintainability

The on-site MTTR is 0.5 hour achieved by modularity and BITE compatibility. Ninety-five percent of system failures will occur at the LRU level and the BITE will penetrate to these LRU's.

Preventive maintenance totals approximately 450 man-hours per year of which only 25 hours require the system to be "down". Preventive maintenance materials consist of low-cost consumables estimated at approximately $100/system per year.

All maintenance, corrective and preventive, can be accomplished by a single AFSC-5 level technician. No outside assistance involving higher skills is involved. Certain maintenance actions could require unskilled assistance due to safety requirements or weight/size of a maintenance item.

3.3.5 Reliability

High reliability techniques and solid-state technology are used throughout the design. The system also contains relatively few life-limited items. At present, these have been defined as TWT, CRT, Spark gaps, TR limiter, blower and coolant pump motors. All these items exhibit some condition of wear and can be scheduled for replacement. The TWT is repairable as are all motors and pumps. System reliability is described in Volume II, the technical description.

3.3.6 Test Equipment

All common test equipment required exist in the USAF inventory. No special tools and test equipment are required on-site. A commercially available digital tester will be furnished as CFE for each site. Depot special hi-cost test equipment, consisting of six items will be CFE. No special tools are required at depot.

APPENDIX A

PRICE MODEL PRINTOUTS FOR THE BASELINE UNATTENDED RADAR

```
INPUT DATA
QTY        160. PROTOS    4.0 WT       1.500 VOL       0.037 MODE       1.
QTYSYS       2. INTEGE  0.500 INTEGS   0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS      0.520 MCPLXS  6.002 PRODS    4.473 NEWST     1.000 DESRPS    0.000

ELECTRONICS
USEVOL  0.697 MCPLXE  8.451 PRODE    4.722 NEWEL     1.000 DESRPE    0.000
PWR     2.500 CMPNTS     0. CMPID    0.000 PWRFAC    2.500 CMPEFF    0.000

ENGINEERING
ENMTHS    1.0 ENMTHP    0.0 ENMTHT     0.0 ECMPLX    1.752 PRNF      0.000

PRODUCTION
PRMTHS   34.0 PRMTHF   66.0 LCURVE   0.950 ECNE      0.000 ECNS      0.000

GLOBAL
YEAR    1978. ESC     0.00% PROJCT   1.000 DATA      1.000 TLGTST    2.000
PLATFM  1.950 SYSTEM  1.000 PPROJ    1.000 PDATA     1.000 PTLGTS     1.00

PROGRAM COST           DEVELOPMENT        PRODUCTION         TOTAL COST
ENGINEERING
 DRAFTING                      85.                6.                91.
 DESIGN                       312.               21.               333.
 SYSTEMS                       96.                0.                96.
 PROJ MGMT                     62.               23.                85.
 DATA                          34.                2.                35.
  SUBTOTAL(ENG)               589.               52.               640.

MANUFACTURING
 PRODUCTION                     0.              409.               409.
 PROTOTYPE                     24.                0.                24.
 TOOL-TEST EQ                  11.               12.                24.
  SUBTOTAL(MFG)                35.              421.               456.

  TOTAL COST                  624.              472.              1096.

VOL       0.037 AVCOST     2.55 TOTAL AV PROD COST     2.95 LCURVE  0.950
WT        1.500 ECNE      0.092 ECNS     0.026 DESRPE 0.000 DESRPS  0.000

MECH/STRUCT
WS        0.520 WSCF     14.054 MECID    0.000 PRODS  4.473 MCPLXS  6.002
ELECTRONICS
WE        0.980 WECF     30.000 CMPID    0.000 PRODE  4.722 MCPLXE  8.451
PWR       2.500 CMPNTS   219.                  PWRFAC 2.500 CMPEFF -6.909

SCHEDULES
ENMTHS  1.000 ENMTHP  23.225 ENMTHT 23.225 ECMPLX 1.752 PRNF      0.000
PRMTHS 34.000 PRMTHF  66.000 AVER. PROD RATE PER MONTH            5.000

COST RANGES            DEVELOPMENT        PRODUCTION         TOTAL COST
      FROM                    563.              407.               970.
      CENTER                  624.              472.              1096.
      TO                      706.              556.              1262.
```

Figure A-1. RF Receiver

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```
INPUT DATA
QTY        80. PROTOS    2.0 WT       1.500 VOL       0.037 MODE      1.
QTYSYS      1. INTEGE  0.700 INTEGS   0.300 AMULTE  106.50% AMULTM 106.50%

MECH/STRUCT
WS      0.520 MCPLXS   6.002 PRODS    4.473 MEWST     1.000 DESRPS   0.000

ELECTRONICS
USEVOL  0.697 MCPLXE   8.451 PRODE    4.722 MEWEL     0.800 DESRPE   0.200
PWR     2.500 CMPNTS      0. CMPID    0.000 PWRFAC    2.500 CMPEFF   0.000

ENGINEERING
ENMTHS    1.0 ENMTHP     0.0 ENMTHT     0.0 ECMPLX    1.546 PRNF     0.000

PRODUCTION
PRMTHS   34.0 PRMTHF    66.0 LCURVE   0.950 ECNE      0.000 ECNS     0.000

GLOBAL
YEAR    1978. ESC      0.00% PROJCT   1.000 DATA      1.000 TLGTST   2.000
PLATFM  1.950 SYSTEM   1.000 PPROJ    1.000 PDATA     1.000 PTLGTS    1.00

PROGRAM COST          DEVELOPMENT        PRODUCTION        TOTAL COST
ENGINEERING
 DRAFTING                     49.                5.               55.
 DESIGN                      175.               17.              192.
 SYSTEMS                      46.                0.               46.
 PROJ MGMT                    30.               13.               42.
 DATA                         15.                1.               16.
  SUBTOTAL(ENG)              315.               36.              351.

MANUFACTURING
 PRODUCTION                    0.              212.              212.
 PROTOTYPE                    12.                0.               12.
 TOOL-TEST EQ                  7.                7.               14.
  SUBTOTAL(MFG)               19.              219.              238.

  TOTAL COST                 334.              255.              589.

VOL       0.037 AVCOST    2.65 TOTAL AV PROD COST    3.19 LCURVE  0.950
WT        1.500 ECNE     0.092 ECNS     0.026 DESRPE 0.200 DESRPS  0.000

MECH/STRUCT
WS        0.520 WSCF    14.054 MECID    0.000 PRODS  4.473 MCPLXS  6.002
ELECTRONICS
WE        0.980 WECF    38.000 CMPID    0.000 PRODE  4.722 MCPLXE  8.451
PWR       2.500 CMPNTS   219.                 PWRFAC 2.500 CMPEFF -6.909

SCHEDULES
ENMTHS  1.000 ENMTHP  20.493 ENMTHT 20.493 ECMPLX 1.546 PRNF      0.000
PRMTHS 34.000 PRMTHF  66.000 AVER. PROD RATE PER MONTH          2.500

COST RANGES           DEVELOPMENT        PRODUCTION        TOTAL COST
      FROM                   301.              220.              521.
      CENTER                 334.              255.              589.
      TO                     379.              299.              677.
```

Figure A-2. IF Receiver

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```
INPUT DATA
QTY          80. PROTOS     2.0 NT        1.300 VOL        0.037 MODE       1.
QTYSYS        1. INTEGE   0.500 INTEGS    0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS        0.520 MCPLXS   6.002 PRODS     4.473 NEWST      1.000 DESRPS    0.000

ELECTRONICS
USEVOL    0.555 MCPLXE   8.451 PRODE     4.722 NEWEL      1.000 DESRPE    0.000
PWR       3.000 CMPNTS      0. CMPID     0.000 PWRFAC     2.500 CMPEFF    0.000

ENGINEERING
ENMTHS      1.0 ENMTHP     0.0 ENMTHT      0.0 ECMPLX     0.825 PRNF      0.000

PRODUCTION
PRMTHS     34.0 PRMTHF    66.0 LCURVE    0.950 ECNE       0.000 ECNS      0.000

GLOBAL
YEAR      1978. ESC      0.00% PROJCT    1.000 DATA       1.000 TLGTST    2.000
PLATFM    1.950 SYSTEM   1.000 PPROJ     1.000 PDATA      1.000 PTLGTS     1.00

PROGRAM COST            DEVELOPMENT         PRODUCTION        TOTAL COST
ENGINEERING
 DRAFTING                       34.                 6.               41.
 DESIGN                        101.                21.              122.
 SYSTEMS                        12.                 0.               12.
 PROJ MGMT                      11.                11.               23.
 DATA                            5.                 1.                6.
  SUBTOTAL(ENG)                164.                40.              203.

MANUFACTURING
 PRODUCTION                      0.               183.              183.
 PROTOTYPE                       8.                 0.                8.
 TOOL-TEST EQ                    3.                 6.                9.
  SUBTOTAL(MFG)                 11.               189.              200.

  TOTAL COST                   174.               229.              403.

VOL        0.037 AVCOST     2.28 TOTAL AV PROD COST     2.86 LCURVE  0.950
WT         1.300 ECNE      0.092 ECNS      0.026 DESRPE 0.000 DESRPS  0.000

MECH/STRUCT
WS         0.520 WSCF     14.054 MECID     0.000 PRODS  4.473 MCPLXS  6.002
ELECTRONICS
WE         0.780 WECF     38.000 CMPID     0.000 PRODE  4.722 MCPLXE  8.451
PWR        3.000 CMPNTS     262.                  PWRFAC 2.500 CMPEFF  1.194

SCHEDULES
ENMTHS  1.000 ENMTHP  10.928 ENMTHT 10.928 ECMPLX 0.825 PRNF      0.000
PRMTHS 34.000 PRMTHF  66.000 AVER. PROD RATE PER MONTH            2.500

COST RANGES             DEVELOPMENT         PRODUCTION        TOTAL COST
      FROM                     157.               198.              356.
      CENTER                   174.               229.              403.
      TO                       197.               267.              464.
```

Figure A-3. Radar Exciter

```
INPUT DATA
QTY          80. PROTOS     2.0 WT        1.400 VOL        0.037 MODE       1.
QTYSYS        1. INTEGE  0.500 INTEGS   0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS        0.520 MCPLXS  6.002 PRODS    4.473 NEWST     1.000 DESRPS    0.000

ELECTRONICS
USEVOL   0.626 MCPLXE  8.451 PRODE    4.722 NEWEL     1.000 DESRPE    0.000
PWR      1.000 CMPNTS      0. CMPID    0.000 PWRFAC    2.500 CMPEFF    0.000

ENGINEERING
ENMTHS      1.0 ENMTHP     0.0 ENMTHT     0.0 ECMPLX    1.031 PRNF      0.000

PRODUCTION
PRMTHS     34.0 PRMTHF    66.0 LCURVE  0.950 ECNE      0.000 ECNS      0.000

GLOBAL
YEAR      1978. ESC      0.00% PROJCT  1.000 DATA      1.000 TLGTST    2.000
PLATFM   1.950 SYSTEM  1.000 PPROJ   1.000 PDATA     1.000 PTLGTS     1.00

PROGRAM COST              DEVELOPMENT          PRODUCTION          TOTAL COST
ENGINEERING
 DRAFTING                         47.                  7.                 53.
 DESIGN                          146.                 22.                168.
 SYSTEMS                          23.                  0.                 23.
 PROJ MGMT                        15.                 12.                 27.
 DATA                              7.                  1.                  8.
  SUBTOTAL(ENG)                  237.                 42.                279.

MANUFACTURING
 PRODUCTION                        0.                200.                200.
 PROTOTYPE                         9.                  0.                  9.
 TOOL-TEST EQ                      4.                  7.                 11.
  SUBTOTAL(MFG)                   13.                207.                220.

  TOTAL COST                     250.                249.                499.

VOL       0.037 AVCOST     2.50 TOTAL AV PROD COST     3.11 LCURVE  0.950
WT        1.400 ECNE     0.092 ECNS     0.026 DESRPE 0.000 DESRPS  0.000

MECH STRUCT
WS        0.520 WSCF    14.054 MECID    0.000 PRODS  4.473 MCPLXS  6.002
ELECTRONICS
WE        0.380 WECF    38.000 CMPID    0.000 PRODE  4.722 MCPLXE  8.451
PWR       1.000 CMPNTS      87.                PWRFAC 2.500 CMPEFF-22.860

SCHEDULES
ENMTHS   1.000 ENMTHP  13.661 ENMTHT 13.661 ECMPLX 1.031 PRNF     0.000
PRMTHS  34.000 PRMTHF  66.000 AVER. PROD RATE PER MONTH           2.500

COST RANGES               DEVELOPMENT          PRODUCTION          TOTAL COST
      FROM                       225.                216.                441.
      CENTER                     250.                249.                499.
      TO                         284.                291.                575.
```

Figure A-4. IFF Receiver

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```
INPUT DATA
QTY         30. PROTOS     2.0 WT        1.300 VOL        0.037 MODE       1.
QTYSYS       1. INTEGE  0.500 INTEGS  0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS       0.520 MCPLXS  6.002 PRODS    4.473 NEWST      1.000 DESRPS    0.000

ELECTRONICS
USEVOL   0.555 MCPLXE  8.451 PRODE    4.722 NEWEL      1.000 DESRPE    0.000
PWR      2.000 CMPNTS      0. CMPID   0.000 PWRFAC     2.500 CMPEFF    0.000

ENGINEERING
ENMTHS     1.0 ENMTHP     0.0 ENMTHT     0.0 ECMPLX    0.825 PRNF      0.000

PRODUCTION
PRMTHS    34.0 PRMTHF    66.0 LCURVE  0.950 ECNE       0.000 ECNS      0.000

GLOBAL
YEAR     1978. ESC     0.00% PROJCT  1.000 DATA       1.000 TLGTST    2.000
PLATFM   1.950 SYSTEM  1.000 PPROJ   1.000 PDATA      1.000 PTLGTS     1.00

PROGRAM COST              DEVELOPMENT        PRODUCTION        TOTAL COST
ENGINEERING
 DRAFTING                         34.                6.                41.
 DESIGN                          101.               21.               122.
 SYSTEMS                          12.                0.                12.
 PROJ MGMT                        11.               11.                23.
 DATA                              5.                1.                 6.
  SUBTOTAL(ENG)                  164.               40.               203.

MANUFACTURING
 PRODUCTION                        0.              183.               183.
 PROTOTYPE                         8.                0.                 8.
 TOOL-TEST EQ                      3.                6.                 9.
  SUBTOTAL(MFG)                   11.              189.               200.

  TOTAL COST                     174.              229.               403.

VOL        0.037 AVCOST    2.28 TOTAL AV PROD COST    2.86 LCURVE  0.950
WT         1.300 ECNE     0.092 ECNS     0.026 DESRPE 0.000 DESRPS  0.000

MECH/STRUCT
WS         0.520 WSCF    14.054 MECID    0.000 PRODS  4.473 MCPLXS  6.002
ELECTRONICS
WE         0.780 WECF    38.000 CMPID    0.000 PRODE  4.722 MCPLXE  8.451
PWR        2.000 CMPNTS   175.                PWRFAC 2.500 CMPEFF -6.805

SCHEDULES
ENMTHS   1.000 ENMTHP  10.928 ENMTHT 10.928 ECMPLX 0.825 PRNF      0.000
PRMTHS  34.000 PRMTHF  66.000 AVER. PROD RATE PER MONTH            2.500

COST RANGES               DEVELOPMENT        PRODUCTION        TOTAL COST
      FROM                       157.              198.               356.
      CENTER                     174.              229.               403.
      TO                         197.              267.               464.
```

Figure A-5. IFF Exciter

BEST AVAILABLE COPY

```
INPUT DATA
QTY         80. PROTOS    2.0 WT        2.510 VOL       0.100 MODE      1.
QTYSYS       1. INTEGE  0.500 INTEGS    0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS       1.230 MCPLXS  5.997 PRODS     4.508 NEWST     1.000 DESRPS   0.500

ELECTRONICS
USEVOL   0.337 MCPLXE  8.451 PRODE     4.722 NEWEL     0.700 DESRPE   0.000
PWR     10.000 CMPNTS     0. CMPID     0.000 PWRFAC    2.500 CMPEFF   0.000

ENGINEERING
ENMTHS     1.0 ENMTHP    0.0 ENMTHT      0.0 ECMPLX    1.546 PRNF     0.000

PRODUCTION
PRMTHS    34.0 PRMTHF   66.0 LCURVE    0.950 ECNE      0.000 ECNS     0.000

GLOBAL
YEAR     1978. ESC     0.00% PROJCT    1.000 DATA      1.000 TLGTST   2.000
PLATFM   1.950 SYSTEM  1.000 PPROJ     1.000 PDATA     1.000 PTLGTS    1.00

PROGRAM COST            DEVELOPMENT         PRODUCTION          TOTAL COST
ENGINEERING
 DRAFTING                       64.                 8.                 71.
 DESIGN                        225.                25.                250.
 SYSTEMS                        59.                 0.                 59.
 PROJ MGMT                      38.                17.                 55.
 DATA                           20.                 1.                 21.
  SUBTOTAL(ENG)                405.                51.                457.

MANUFACTURING
 PRODUCTION                      0.               279.                279.
 PROTOTYPE                      16.                 0.                 16.
 TOOL-TEST EQ                    9.                 9.                 17.
  SUBTOTAL(MFG)                 25.               288.                313.

  TOTAL COST                   430.               339.                769.

VOL        0.100 AVCOST      3.49 TOTAL AV PROD COST    4.24 LCURVE  0.950
WT         2.510 ECNE       0.092 ECNS      0.026 DESRPE 0.000 DESRPS  0.500

MECH/STRUCT
WS         1.230 WSCF      12.300 MECID     0.000 PRODS  4.508 MCPLXS  5.997
ELECTRONICS
WE         1.280 WECF      38.000 CMPID     0.000 PRODE  4.722 MCPLXE  8.451
PWR       10.000 CMPNTS      875.                 PWRFAC 2.500 CMPEFF 15.166

SCHEDULES
ENMTHS   1.000 ENMTHP  20.495 ENMTHT 20.495 ECMPLX 1.546 PRNF        0.000
PRMTHS  34.000 PRMTHF  66.000 AVER. PROD RATE PER MONTH              2.500

COST RANGES             DEVELOPMENT         PRODUCTION          TOTAL COST
     FROM                      388.               293.                682.
     CENTER                    430.               339.                769.
     TO                        487.               397.                884.
```

Figure A-6. Synthesizer

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INPUT DATA

QTY	30.	PROTOS	2.00	UVCOST	16.000	AMULTM	115.00%
,LCURVE	0.850						
WT	50.000	QTYSYS	1.				

MECH/STRUCT

WS	30.000	INTEGS	0.300	MCPLXS	6.055

ELECTRONICS

WE	20.000	INTEGE	0.300	MCPLXE	7.900

PROGRAM COST	DEVELOPMENT	PRODUCTION	TOTAL COST
PURCH ITEM	37.	1472.	1509.

Figure A-7. Receiver/Exciter/Synthesizer Purchase Parts

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```
INPUT DATA
QTY         30. PROTOS     2.0 WT       94.000 VOL       5.670 MODE      1.
QTYSYS       1. INTEGE  0.400 INTEGS  0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS      55.000 MCPLXS  5.725 PRODS    4.371 NEWST     0.500 DESRPS    0.500

ELECTRONICS
USEVOL  0.181 MCPLXE  8.173 PRODE    4.567 NEWEL     1.000 DESRPE    0.000
PWR     90.000 CMPNTS      0. CMPID    0.000 PWRFAC    2.500 CMPEFF    0.000

ENGINEERING
ENMTHS     1.0 ENMTHP     0.0 ENMTHT     0.0 ECMPLX    1.240 PRNF      0.000

PRODUCTION
PRMTHS    34.0 PRMTHF    66.0 LCURVE  0.950 ECNE      0.000 ECNS      0.000

GLOBAL
YEAR     1978. ESC     0.00% PROJCT  1.000 DATA      1.000 TLGTST    2.000
PLATFM   1.950 SYSTEM  1.000 PPROJ   1.000 PDATA     1.000 PTLGTS     1.00

PROGRAM COST              DEVELOPMENT         PRODUCTION          TOTAL COST
ENGINEERING
 DRAFTING                         684.                76.                760.
 DESIGN                          2238.               240.               2478.
 SYSTEMS                          458.                 0.                458.
 PROJ MGMT                        300.               246.                546.
 DATA                             145.                17.                162.
  SUBTOTAL(ENG)                  3825.               579.               4404.

MANUFACTURING
 PRODUCTION                         0.              4509.               4509.
 PROTOTYPE                        248.                 0.                248.
 TOOL-TEST EQ                      98.                79.                176.
  SUBTOTAL(MFG)                   345.              4588.               4933.

  TOTAL COST                     4171.              5167.               9337.

VOL        5.670 AVCOST    56.37 TOTAL AV PROD COST    64.58 LCURVE  0.950
WT        94.000 ECNE      0.085 ECNS     0.024 DESRPE 0.000 DESRPS  0.500

MECH/STRUCT
WS        55.000 WSCF      9.700 MECID    0.000 PRODS  4.371 MCPLXS  5.725
ELECTRONICS
WE        39.000 WECF     38.000 CMPID    0.000 PRODE  4.567 MCPLXE  8.173
PWR       90.000 CMPNTS    7872.                PWRFAC 2.500 CMPEFF -7.418

SCHEDULES
ENMTHS   1.000 ENMTHP  15.860 ENMTHT 15.860 ECMPLX 1.240 PRNF      0.000
PRMTHS  34.000 PRMTHF  66.000 AVER. PROD RATE PER MONTH           2.500

COST RANGES               DEVELOPMENT         PRODUCTION          TOTAL COST
      FROM                       3747.              4408.               8155.
      CENTER                     4171.              5167.               9337.
      TO                         4758.              6171.              10929.
```

Figure A-8. Signal Processor

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```
INPUT DATA
QTY         80. PROTOS     2.0 WT       20.000 VOL        0.700 MODE       1.
QTYSYS       1. INTEGE   0.400 INTEGS    0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS       9.400 MCPLXS   5.730 PRODS     4.283 NEWST      1.000 DESRPS    2.000

ELECTRONICS
USEVOL  0.303 MCPLXE   7.810 PRODE     4.176 NEWEL      1.000 DESRPE    2.000
PWR   100.000 CMPNTS      0. CMPID     0.000 PWRFAC     0.700 CMPEFF    0.000

ENGINEERING
ENMTHS     1.0 ENMTHP     0.0 ENMTHT     0.0 ECMPLX     1.250 PRNF      0.000

PRODUCTION
PRMTHS    34.0 PRMTHF    66.0 LCURVE   0.950 ECNE       0.000 ECNS      0.000

GLOBAL
YEAR     1978. ESC      0.00% PROJCT   1.000 DATA       1.000 TLGTST    2.000
PLATFM   1.950 SYSTEM   1.000 PPROJ    1.000 PDATA      1.000 PTLGTS     1.00

PROGRAM COST              DEVELOPMENT         PRODUCTION          TOTAL COST
ENGINEERING
 DRAFTING                        167.                16.                183.
 DESIGN                          541.                45.                586.
 SYSTEMS                         116.                 0.                116.
 PROJ MGMT                        76.                56.                132.
 DATA                             37.                 4.                 41.
  SUBTOTAL(ENG)                  938.               121.               1059.

MANUFACTURING
 PRODUCTION                        0.              1030.               1030.
 PROTOTYPE                        58.                 0.                 58.
 TOOL-TEST EQ                     25.                27.                 51.
  SUBTOTAL(MFG)                   82.              1056.               1139.

  TOTAL COST                    1020.              1177.               2197.

VOL       0.700 AVCOST    12.87 TOTAL AV PROD COST    14.72 LCURVE  0.950
WT       20.000 ECNE      0.075 ECNS     0.024 DESRPE 0.333 DESRPS  0.233

MECH/STRUCT
WS        9.400 WSCF     13.429 MECID    0.000 PRODS   4.283 MCPLXS  5.730
ELECTRONICS
WE       10.600 WECF     50.000 CMPID    0.000 PRODE   4.176 MCPLXE  7.810
PWR     100.000 CMPNTS    1308.                PWRFAC  0.700 CMPEFF 10.085

SCHEDULES
ENMTHS    1.000 ENMTHP   15.193 ENMTHT 15.193 ECMPLX 1.250 PRNF     0.000
PRMTHS   34.000 PRMTHF   66.000 AVER. PROD RATE PER MONTH           2.500

COST RANGES               DEVELOPMENT         PRODUCTION          TOTAL COST
       FROM                      908.               998.               1905.
       CENTER                   1020.              1177.               2197.
       TO                       1185.              1440.               2625.
```

Figure A-9. Power Supplies

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```
INPUT DATA
QTY         80. PROTOS    2.0 WT     40.000 VOL       1.800 MODE      1.
QTYSYS       1. INTEGE  0.600 INTEGS  0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS      19.000 MCPLXS  5.984 PRODS   4.543 NEWST     1.000 DESRPS   2.000

ELECTRONICS
USEVOL   0.259 MCPLXE  8.661 PRODE   4.710 NEWEL     1.000 DESRPE   2.000
PWR    150.000 CMPNTS     0. CMPID   0.000 PWRFAC    0.500 CMPEFF   0.000

ENGINEERING
ENMTHS     1.0 ENMTHP    0.0 ENMTHT    0.0 ECMPLX    1.237 PRNF     0.000

PRODUCTION
PRMTHS    34.0 PRMTHF   66.0 LCURVE  0.950 ECNE      0.000 ECNS     0.000

GLOBAL
YEAR     1978. ESC     0.00% PROJCT  1.000 DATA      1.000 TLGTST   2.000
PLATFM   1.950 SYSTEM  1.000 PPROJ   1.000 PDATA     1.000 PTLGTS    1.00

PROGRAM COST              DEVELOPMENT       PRODUCTION        TOTAL COST
ENGINEERING
 DRAFTING                        272.              33.              305.
 DESIGN                          906.             107.             1013.
 SYSTEMS                         176.               0.              176.
 PROJ MGMT                       122.             200.              322.
 DATA                             57.              13.               70.
  SUBTOTAL(ENG)                 1533.             352.             1886.

MANUFACTURING
 PRODUCTION                        0.            3938.             3938.
 PROTOTYPE                       202.               0.              202.
 TOOL-TEST EQ                     85.              75.              160.
  SUBTOTAL(MFG)                  287.            4013.             4300.

  TOTAL COST                    1821.            4365.             6186.

VOL      1.800 AVCOST    49.22 TOTAL AV PROD COST   54.56 LCURVE  0.950
WT      40.000 ECNE      0.098 ECNS    0.027 DESRPE 0.536 DESRPS  0.395

MECH/STRUCT
WS      19.000 WSCF     10.556 MECID   0.000 PRODS  4.543 MCPLXS  5.984
ELECTRONICS
WE      21.000 WECF     45.000 CMPID   0.000 PRODE  4.710 MCPLXE  8.661
PWR    150.000 CMPNTS   1188.                PWRFAC 0.500 CMPEFF -3.400

SCHEDULES
ENMTHS   1.000 ENMTHP   16.871 ENMTHT 16.871 ECMPLX 1.237 PRNF    0.000
PRMTHS  34.000 PRMTHF   66.000 AVER. PROD RATE PER MONTH      2.500

COST RANGES               DEVELOPMENT       PRODUCTION        TOTAL COST
      FROM                      1631.            3705.             5336.
      CENTER                    1821.            4365.             6186.
      TO                        2030.            5214.             7293.
```

Figure A-10. Radar Transmitter

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```
INPUT DATA
QTY          80. PROTOS     2.0 WT       5.000 VOL        0.050 MODE       1.
QTYSYS        1. INTEGE   0.500 INTEGS   0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS        0.800 MCPLXS   5.737 PRODS    4.240 NEWST      1.000 DESRPS   2.000

ELECTRONICS
USEVOL    1.867 MCPLXE   8.462 PRODE    4.602 NEWEL      1.000 DESRPE   2.000
PWR       2.000 CMPNTS     25. CMPID    0.000 PWRFAC     0.000 CMPEFF   0.000

ENGINEERING
ENMTHS      1.0 ENMTHP     0.0 ENMTHT     0.0 ECMPLX     1.238 PRNF     0.000

PRODUCTION
PRMTHS     34.0 PRMTHF    66.0 LCURVE   0.950 ECNE       0.000 ECNS     0.000

GLOBAL
YEAR      1978. ESC      0.00% PROJCT   1.000 DATA       1.000 TLGTST   2.000
PLATFM    1.950 SYSTEM   1.000 PPROJ    1.000 PDATA      1.000 PTLGTS    1.00

PROGRAM COST              DEVELOPMENT         PRODUCTION         TOTAL COST
ENGINEERING
 DRAFTING                        108.                13.               121.
 DESIGN                          357.                41.               397.
 SYSTEMS                          71.                 0.                71.
 PROJ MGMT                        46.                41.                88.
 DATA                             22.                 3.                25.
  SUBTOTAL(ENG)                  605.                98.               702.

MANUFACTURING
 PRODUCTION                        0.               754.               754.
 PROTOTYPE                        38.                 0.                38.
 TOOL-TEST EQ                     17.                20.                37.
  SUBTOTAL(MFG)                   55.               774.               829.

  TOTAL COST                     660.               871.              1531.

VOL       0.050 AVCOST      9.42 TOTAL AV PROD COST   10.89 LCURVE  0.950
WT        5.000 ECNE       0.092 ECNS     0.024 DESRPE 0.347 DESRPS -0.190

MECH/STRUCT
WS        0.800 WSCF      16.000 MECID    0.000 PRODS  4.240 MCPLXS  5.737
ELECTRONICS
WE        4.200 WECF      45.000 CMPID    0.000 PRODE  4.602 MCPLXE  8.462
PWR       2.000 CMPNTS    25.                   PWRFAC 0.679 CMPEFF-52.769

SCHEDULES
ENMTHS    1.000 ENMTHP    16.448 ENMTHT 16.448 ECMPLX 1.238 PRNF     0.000
PRMTHS   34.000 PRMTHF    66.000 AVER. PROD RATE PER MONTH           2.500

COST RANGES               DEVELOPMENT         PRODUCTION         TOTAL COST
     FROM                        591.               743.              1334.
     CENTER                      660.               871.              1531.
     TO                          755.              1040.              1794.
```

Figure A-11. IFF Transmitter

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INPUT DATA
QTY 80. PROTOS 2.0 WT 15.000 VOL 2.000 MODE 1.
QTYSYS 1. INTEGE 0.500 INTEGS 0.300 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS 12.100 MCPLXS 5.399 PRODS 4.250 NEWST 1.000 DESRPS 2.000

ELECTRONICS
USEVOL 0.036 MCPLXE 8.455 PRODE 4.686 NEWEL 1.000 DESRPE 2.000
PWR 5.300 CMPNTS 0. CMPID 0.000 PWRFAC 0.500 CMPEFF 0.000

ENGINEERING
ENMTHS 1.0 ENMTHP 0.0 ENMTHT 0.0 ECMPLX 1.340 PRNF 0.000

PRODUCTION
PRMTHS 34.0 PRMTHF 66.0 LCURVE 0.950 ECNE 0.000 ECNS 0.000

GLOBAL
YEAR 1978. ESC 0.00% PROJCT 1.000 DATA 1.000 TLGTST 2.000
PLATFM 1.950 SYSTEM 1.000 PPROJ 1.000 PDATA 1.000 PTLGTS 1.00

PROGRAM COST	DEVELOPMENT	PRODUCTION	TOTAL COST
ENGINEERING			
DRAFTING	105.	10.	115.
DESIGN	355.	33.	388.
SYSTEMS	78.	0.	78.
PROJ MGMT	51.	35.	86.
DATA	25.	2.	27.
SUBTOTAL(ENG)	614.	80.	693.
MANUFACTURING			
PRODUCTION	0.	630.	630.
PROTOTYPE	36.	0.	36.
TOOL-TEST EQ	17.	17.	34.
SUBTOTAL(MFG)	53.	647.	701.
TOTAL COST	667.	727.	1394.

VOL 2.000 AVCOST 7.88 TOTAL AV PROD COST 9.09 LCURVE 0.950
WT 15.000 ECNE 0.092 ECNS 0.020 DESRPE 0.326 DESRPS 0.254

MECH/STRUCT
WS 12.100 WSCF 6.050 MECID 0.000 PRODS 4.250 MCPLXS 5.399
ELECTRONICS
WE 2.900 WECF 40.000 CMPID 0.000 PRODE 4.686 MCPLXE 8.455
PWR 5.300 CMPNTS 42. PWRFAC 0.500 CMPEFF-29.165

SCHEDULES
ENMTHS 1.000 ENMTHP 17.786 ENMTHT 17.786 ECMPLX 1.340 PRNF 0.000
PRMTHS 34.000 PRMTHF 66.000 AVER. PROD RATE PER MONTH 2.500

COST RANGES	DEVELOPMENT	PRODUCTION	TOTAL COST
FROM	599.	625.	1224.
CENTER	667.	727.	1394.
TO	762.	858.	1620.

Figure A-12. Waveguide Switch

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INPUT DATA

```
QTY            80.  PROTOS    2.00  BUCOST    26.000  AMULTN 122.00%
•LCURVE       0.850
 WT       2570.000  QTYSYS       1.

MECH/STRUCT
 WS       2570.000  INTEGS   0.300  MCPLXS  4.731

PROGRAM COST            DEVELOPMENT        PRODUCTION        TOTAL COST
PURCH ITEM                      63.             2538.             2601.
```

Figure A-13. Waveguide

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```
INPUT DATA
QTY         50. PROTOS    2.0 WT    5087.000 VOL  65000.000 MODE      2.
QTYSYS       1. INTEGE  0.000 INTEGS  0.700 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
WS   5087.000 MCPLXS  5.114 PRODS    5.341 MENST     0.300 DESRPS   0.600

ENGINEERING
ENMTHS     1.0 ENMTHP     0.0 ENMTHT     0.0 ECMPLX   1.227 PRNF     0.000

PRODUCTION
PRMTHS    34.0 PRMTHF    66.0 LCURVE  0.950 ECNE     0.000 ECNS     0.000

GLOBAL
YEAR     1978. ESC      0.00% PROJCT  1.000 DATA     1.000 TLGTST   2.000
PLATFM  1.950 SYSTEM  1.000 PPROJ   1.000 PDATA    1.000 PTLGTS    1.00

PROGRAM COST            DEVELOPMENT         PRODUCTION         TOTAL COST
ENGINEERING
 DRAFTING                       132.                12.               144.
 DESIGN                         369.                43.               412.
 SYSTEMS                        109.                 0.               109.
 PROJ MGNT                      151.               467.               617.
 DATA                            57.                29.                86.
  SUBTOTAL(ENG)                 819.               550.              1369.

MANUFACTURING
 PRODUCTION                       0.             10321.             10321.
 PROTOTYPE                     1039.                 0.              1039.
 TOOL-TEST EQ                   195.                60.               255.
  SUBTOTAL(MFG)                1234.             10381.             11615.

  TOTAL COST                   2053.             10930.             12984.

VOL  65000.000 AVCOST   129.01 TOTAL AV PROD COST  136.63 LCURVE  0.950
WT    5087.000 ECNE     0.001 ECNS    0.018 DESRPE 0.000 DESRPS  0.600

MECH/STRUCT
WS    5087.000 WSCF     0.078 MECID   0.000 PRODS  5.341 MCPLXS  5.114

SCHEDULES
ENMTHS   1.000 ENMTHP   9.411 ENMTHT  9.411 ECMPLX 1.227 PRNF    0.000
PRMTHS  34.000 PRMTHF  66.000 AVER. PROD RATE PER MONTH          2.500

COST RANGES             DEVELOPMENT         PRODUCTION         TOTAL COST
      FROM                     1876.              9748.             11624.
      CENTER                   2053.             10930.             12984.
      TO                       2274.             12175.             14449.
```

Figure A-14. Antenna

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INPUT DATA

```
QTY          80.  PROTOS    2.00  BVCOST     14.000  AMULTM 122.00%
,LCURVE      0.850
 WT          25.000  QTYSYS     1.

MECH/STRUCT
 WS           3.600  INTEGS   0.300  MCPLXS  5.693
ELECTRONICS
 WE          21.400  INTEGE   0.500  MCPLXE  7.850

PROGRAM COST           DEVELOPMENT        PRODUCTION        TOTAL COST
PURCH ITEM                    34.              1366.        1401.
```

Figure A-15. Data Processor

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```
INPUT DATA
QTY        80. PROTOS    2.0 INT    221.270 IVOL      14.150 MODE       5.
QTYSYS      1. INTEGE  0.000 INTEGS   0.000 AMULTE 106.50% AMULTM 106.50%

MECH/STRUCT
IWS   212.247 MCPLXS  4.658 PRODS    0.000 NEWST     0.300 DESRPS    0.000

ELECTRONICS
I-VVOL  0.018 MCPLXE  7.688 PRODE    0.000 NEWEL     0.300 DESRPE    0.000
PWR     0.000 CMPNTS  0.000 CMPID    0.000 PWRFAC    0.000 CMPEFF    0.000

ENGINEERING
ENMTHS    1.0 ENMTHP    0.0 ENMTHT     0.0 ECMPLX    0.900 PRNF      0.000

PRODUCTION
PRMTHS   34.0 PRMTHF   66.0 LCURVE   0.000 ECNE      0.000 ECNS      0.000

GLOBAL
YEAR    1978. ESC     0.00% PROJCT   1.000 DATA      1.000 TLGTST    2.000
PLATFM  1.800 SYSTEM  1.000 PPROJ    1.000 PDATA     1.000 PTLGTS     1.00

PROGRAM COST            DEVELOPMENT       PRODUCTION        TOTAL COST
ENGINEERING
 DRAFTING                       50.              19.               69.
 DESIGN                        145.              57.              201.
 SYSTEMS                        21.               0.               21.
 PROJ MGMT                      20.              65.               85.
 DATA                            9.               3.               12.
  SUBTOTAL(ENG)                244.             144.              388.

MANUFACTURING
 PRODUCTION                      0.            1184.             1184.
 PROTOTYPE                      74.               0.               74.
 TOOL-TEST EQ                   30.              29.               59.
  SUBTOTAL(MFG)                104.            1213.             1317.

  TOTAL COST                   348.            1357.             1705.

COST RANGES             DEVELOPMENT       PRODUCTION        TOTAL COST
     FROM                      307.            1133.             1440.
     CENTER                    348.            1357.             1705.
     TO                        411.            1722.             2133.
```

Figure A-16. Integration and Test

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TOTAL COST, LESS INTEGRATION COST

PROGRAM COST	DEVELOPMENT	PRODUCTION	TOTAL COST
ENGINEERING			
DRAFTING	1780.	199.	1979.
DESIGN	5824.	636.	6460.
SYSTEMS	1258.	0.	1258.
PROJ MGMT	914.	1132.	2046.
DATA	431.	73.	504.
SUBTOTAL (ENG)	10207.	2040.	12246.
MANUFACTURING			
PRODUCTION	0.	22646.	22646.
PROTOTYPE	1697.	0.	1697.
TOOL-TEST EQ	473.	325.	797.
PURCH ITEMS	134.	5376.	5510.
SUBTOTAL (MFG)	2305.	28347.	30651.
TOTAL COST	12511.	30386.	42898.

COST RANGES	DEVELOPMENT	PRODUCTION	TOTAL COST
FROM	11279.	27136.	38415.
CENTER	12511.	30386.	42898.
TO	14198.	34349.	48547.

TOTAL COST, WITH INTEGRATION COST

PROGRAM COST	DEVELOPMENT	PRODUCTION	TOTAL COST
ENGINEERING			
DRAFTING	1830.	218.	2048.
DESIGN	5968.	693.	6661.
SYSTEMS	1278.	0.	1278.
PROJ MGMT	935.	1196.	2131.
DATA	439.	76.	516.
SUBTOTAL (ENG)	10450.	2183.	12634.
MANUFACTURING			
PRODUCTION	0.	23831.	23831.
PROTOTYPE	1771.	0.	1771.
TOOL-TEST EQ	503.	353.	856.
PURCH ITEMS	134.	5376.	5510.
SUBTOTAL (MFG)	2409.	29560.	31969.
TOTAL COST	12859.	31744.	44603.

COST RANGES	DEVELOPMENT	PRODUCTION	TOTAL COST
FROM	11586.	28268.	39354.
CENTER	12859.	31744.	44603.
TO	14608.	36072.	50680.

Figure A-17. Total Cost

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